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DEPARTMENT OF DEFENSE HANDBOOK

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS AND SPECTRUM CERTIFICATION GUIDANCE FOR THE ACQUISITION PROCESS

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Foreword

1. This handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. This handbook provides guidance for establishing an effective electromagnetic environmental effects (E3) and spectrum certification (SC) program throughout the life cycle of platforms, systems, subsystems, and equipment.

4. This handbook was prepared in accordance with the guidelines of the Standardization Reform Policy established by the Secretary of Defense.

5. Beneficial comments (recommendations, additions, or deletions) and any pertinent data that may be of use in improving this document should be addressed to:

Defense Information Systems Agency (DISA)
Joint Spectrum Center (JSC)
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2004 Turbot Landing
Annapolis, MD 21402-5064

by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Purpose

This handbook provides acquisition personnel responsible for the design, development, and procurement of Department of Defense (DoD) platforms/systems and subsystems/equipment with the guidance necessary for achieving the desired level of electromagnetic (EM) compatibility (EMC). This handbook describes the tasks that should be accomplished to ensure electromagnetic environmental effects (E3) control and spectrum certification (SC) procedures are addressed during the item's acquisition life cycle.

This handbook is consistent with the policies and procedures of DoD Directives (DoDD) 5000.1, 3222.3, and 4650.1, DoD Instruction (DoDI) 5000.2, and DoD Regulation (DoDR) 5000.2-R. Provisions of this handbook should be used by research, development and acquisition activities, at appropriate times during the life cycle of any item which emits or which can be susceptible to electromagnetic energy either through intentional antennas or through other electromagnetic coupling mechanisms. Essentially, all electronics items and many electrical items fall into this classification. For example, the handbook may be used:

- During acquisition to assure visibility, accountability, and controllability of the E3/SC effort, as well as its integration into the overall program, or

- During the design process to assure management awareness and cost effective tailoring of applicable E3 performance requirements and interface standards.

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1.2 Background

The E3 and spectrum management (SM) disciplines are often represented by different organizations in Military Agencies; however, there is substantial commonality between the concerns of the two disciplines. The SM discipline is involved with planning, coordinating, and managing Joint use of the electromagnetic spectrum by systems that radiate or receive radio frequency (RF) energy to ensure compatible operations. SM includes operational, engineering, and administrative procedures to accomplish EMC. The E3 discipline is concerned with minimizing the impact of the electromagnetic environment (EME) on equipment, systems, and platforms. The complex military EME is composed of radiated and conducted emissions from intentional and unintentional radiators, such as high-powered transmitters from military forces and the civilian infrastructure, electromagnetic pulse (EMP), lightning, precipitation static (p-static), unshielded cables, and so forth. The interrelationship between E3 and SM is depicted in Figure 1. As shown, an overlap occurs, primarily, with assuring the EMC and preventing electromagnetic interference (EMI) with spectrum dependent equipment.

The increase in operational E3 and SM issues have made it necessary for the Director, Operational

Test and Evaluation (DOT&E) to place greater emphasis on these requirements during Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) events. Joint and Allied operations have been victimized by E3 problems and SM conflicts between forces that have resulted in platform loss, reduced mission effectiveness, and increased operational restrictions. Furthermore, deployments of United States (U.S.) military command, control, communications, computers, and intelligence (C4I) assets to foreign nations have resulted in the denial to operate these assets and even confiscation due to lack of SC, that is, Host Nation Approval (HNA). Operational impact assessments of E3 and SM issues need to be accomplished during all life-cycle phases of the acquisition process and reviewed at each milestone decision point. The DoD can reduce this negative impact to military operations by ensuring that platform, system, and equipment limitations and vulnerabilities are mitigated and/or sufficiently documented for the warfighter.

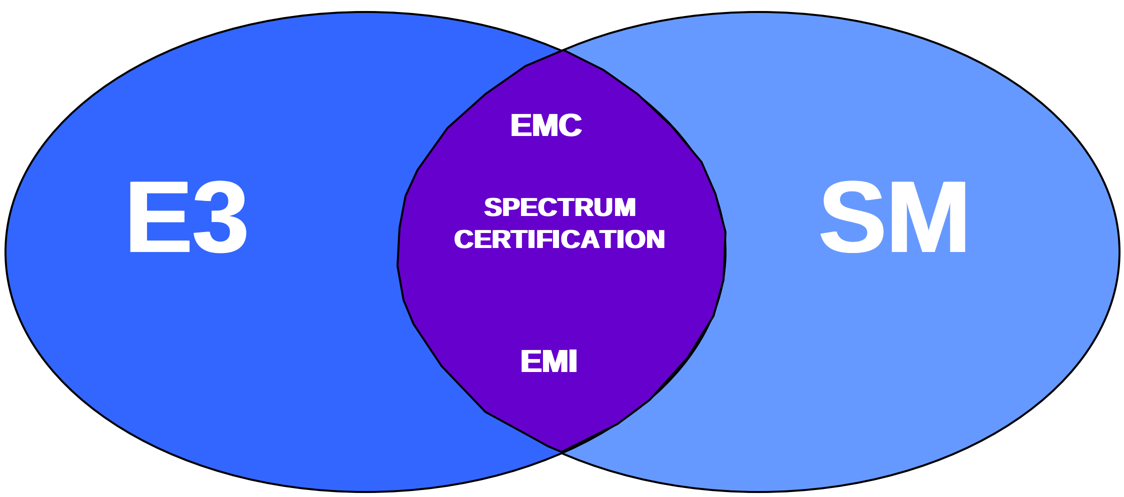

FIGURE 1. Spectrum Certification, the Overlap Between E3 and SM.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed below are only a portion of those referenced herein. These documents are the most relevant to fully understand the information provided by this handbook. A detailed bibliography is presented in Appendix A and in the Engineering Practice Study (EPS) report referenced herein.

2.2 Government Documents

2.2.1 Specifications, Standards, and Handbooks

The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

Department of Defense

MIL-STD-461	Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	Interface Standard, Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-469	Interface Standard, Radar Engineering Design Requirements, Electromagnetic Compatibility

(Copies of the above standards are available from the DoD Single Stock Point, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094, tel: 215-691-2179).

2.2.2 Other Government Documents and Publications

The following other Government documents and publications specified herein are referenced solely to provide supplemental data and are for informational purposes only.

Department of Defense

DoDD 3222.3	DoD Electromagnetic Compatibility (EMC) Program
DoDD 4630.5	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDI 4630.8	Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDD 4650.1	Management and Use of the Radio Frequency Spectrum
DoDD 5000.1	The Defense Acquisition System

DoDI 5000.2	Operation of the Defense Acquisition System
DoDR 5000.2-R	Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs
DoDI 6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers
Chairman Joint Chiefs of Staff Instruction (CJCSI) 3170.01	Requirements Generation System
CJCSI 6212.01	Interoperability, and Supportability of National Security Systems and Information Technology Systems
DOT&E E3 Policy Memorandum	Policy on Operational Test and Evaluation of Electromagnetic Environmental Effects and Spectrum Management, dated 25 October 1999
EPS-0178	Results of Detailed Comparisons of Individual EMC Requirements and Test Procedures Delineated in Major National and International Commercial Standards with Military Standard MIL-STD-461E
Joint Chiefs of Staff (JCS) Pub. No. 1-02	Department of Defense Dictionary of Military and Associated Terms
Standardization Document (SD)-2	Buying Commercial and Non-Developmental Items
SD-16	Communicating Requirements
Under Secretary of Defense for Acquisition & Technology Memorandum	Requirements for Compliance with Reform Legislation for Information Technology (IT) Acquisitions (Including National Security Systems (NSS)), dated 1 May 1997

National Telecommunications and Information Administration (NTIA)

NTIA Manual	Manual of Regulations and Procedures for Federal Radio Frequency Management

(Copies of DoD Directives, Instructions, and Regulations, are available from the DoD Single Stock Point, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094, tel: 215-691-2179. Copies of the NTIA Manual are available from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954 or it may be downloaded from www.ntia.doc.gov/osmh/redbook/redbook.html. Copies of the EPS are available on the DISA/JSC web site: http://www.jsc.mil/jsce3/emcslsa/library.asp).

2.3 Non-Government Publications

The following document forms a part of this document to the extent specified herein. This document which is DoD adopted is listed in the latest issue of the DoDISS, and supplement thereto.

American National Standards Institute (ANSI)

ANSI/IEEE C63.14	Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD) (DoD Adopted)

(ANSI/IEEE documents are generally available for reference from libraries. They are also distributed among non-Government standards bodies and using Federal Agencies. Copies may be purchased from the Institute of Electrical and Electronics Engineers (IEEE), 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1311, tel: 800-701-4333 or fax: 732-981-9667. Copies are also available on: http://standards.ieee.org.)

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3. DEFINITIONS

3.1 General

A glossary of acronyms and abbreviations used in this handbook, including the appendices, is contained in Appendix B of this handbook.

3.2 Definitions

Many of the terms used in this handbook are defined in ANSI/IEEE C63.14, JCS Pub. No.1-02, or the DoD 5000 series of documents. The following two definitions are repeated herein for ready reference.

3.2.1 Electromagnetic Environmental Effects (E3)

E3 is the impact of the EME upon the operational capability of military forces, equipment, systems, and platforms. It encompasses all electromagnetic disciplines, including electromagnetic compatibility (EMC)/electromagnetic interference (EMI); electromagnetic vulnerability (EMV); electromagnetic pulse (EMP); electronic protection (EP); hazards of electromagnetic radiation to personnel (HERP), ordnance (HERO), and volatile materials such as fuel (HERF); and natural phenomena effects of lightning and precipitation static (p-static). (JCS Pub 1-02 and ANSI/IEEE C63.14).

3.2.2 Spectrum Management (SM)

SM is the planning, coordinating, and managing Joint use of the electromagnetic spectrum through operational, engineering, and administrative procedures, with the objective of enabling electronic systems to perform their functions in the intended EME without causing or suffering unacceptable EMI. (JCS Pub 1-02).

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4. E3/SC IN THE ACQUISITION PROCESS

4.1 Requirements Generation System

The Requirements Generation System, as defined in CJCSI 3170.01, produces information for decision-makers on the projected mission needs of the warfighter. There are a number of key requirements documents used by the DoD in the acquisition process. They promote a consistent approach to stating the requirements. Requirements are generated in many different ways: they are stated or derived; they are interrelated and interdependent; and, they must be traceable throughout. As stated in CJCSI 6212.01, requirements documents, such as the Mission Need Statement (MNS), Capstone Requirements Document (CRD), and Operational Requirements Document (ORD) must address National Security Systems (NSS) and Information Technology Systems (ITS) policies in DoDD 4630.5 and DoDI 4630.8, including those for E3 and SC (see Appendix A). An operational authority other than the user confirms the identified need and operational requirement. These documents are discussed in the following paragraphs. They are to be considered in the context of the overall Defense acquisition management framework, as defined in DoDI 5000.2 and depicted below in Figure 2.

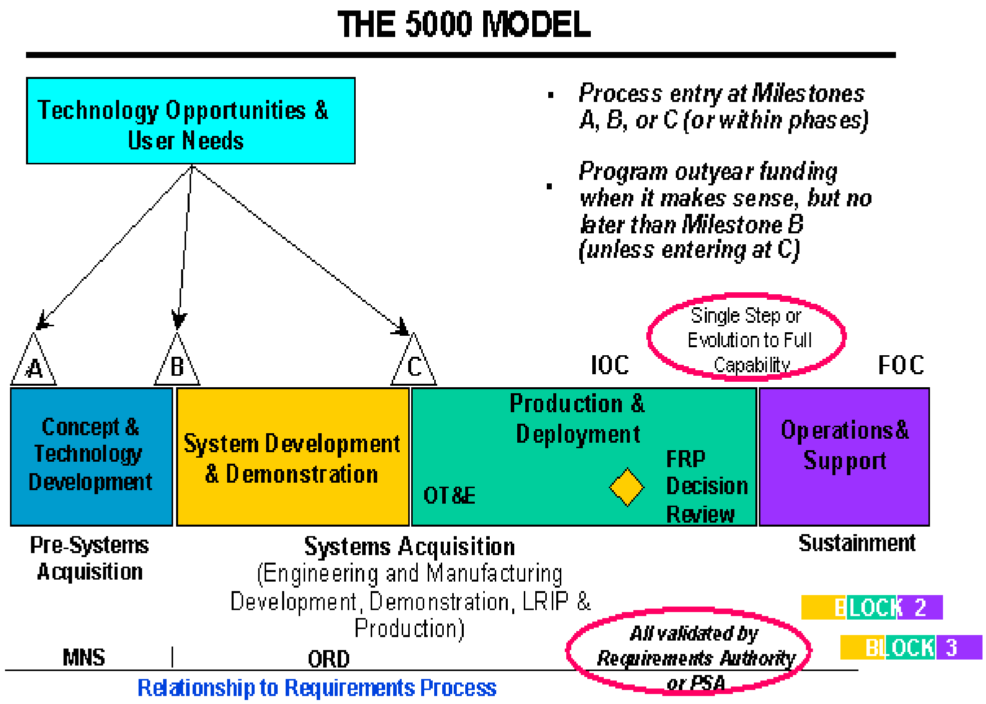

FIGURE 2. Defense Acquisition Management Framework.

4.1.1 Mission Need Statement (MNS)

4.1.1.1 General

The MNS is a formatted non-system-specific statement containing operational capability needs and written in broad operational terms. It describes required operational capabilities and constraints to be studied during Concept and Technology Development. Validation of the MNS is conducted by an authority other than the user and may take place at different organizational levels depending on the MNS origination and potential Acquisition Category (ACAT) level. The MNS is to be prepared in accordance with CJCSI 3170.01 and CJCSI 6212.01.

4.1.1.2 E3/SC Considerations in MNS

From the MNS template in CJCSI 3170.01, as well as CJCSI 6212.01, it is noted that both E3 and SC must be addressed. In accordance with the MNS format in CJCSI 3170.01, E3 and SC should be addressed in *Paragraph 5. Constraints*. The following questions will be addressed in the Joint Staff's review of the MNS:

- Does the MNS address, when applicable, the EME in which the item will be operated?

- Does the MNS address spectrum boundary constraints and certification requirements?

If afforded the opportunity, it is recommended that the following statement be included in the MNS:

> "<u>Spectrum Supportability and Electromagnetic Environmental Effects (E3).</u> The XXXX must be supportable in the electromagnetic spectrum. The XXXX must not be degraded by electromagnetic environmental effects."

E3 problem databases like those of the DISA/JSC and the Services should be researched to determine if there are any E3/SC problems with existing systems and how they were resolved. Furthermore, the *Mission and Threat Analysis* section should include the projected friendly and hostile EME, the Joint or Combined Forces EME, and the potential for an EMP threat, as applicable.

4.1.2 Capstone Requirements Document (CRD)

4.1.2.1 General

The CRD contains capabilities-based requirements that facilitate development of individual ORDs. CRDs are intended to guide the DoD components in developing mission needs and ORDs for future and legacy systems. They are developed for a Joint mission area. A CRD identifies operational concepts, overarching capabilities, and requirements for the mission area family-of-systems (for example, space control, theater missile defense, and so forth) or system-of-systems (such as the national missile defense system). It identifies criteria against which various combinations of systems can be evaluated. The CRD is to be prepared in accordance with CJCSI 3170.01 and CJCSI 6212.01.

4.1.2.2 E3/SC Considerations in CRDs

From the CRD template in CJCSI 3170.01, as well as from CJCSI 6212.01, both E3 and SC must be addressed. The following questions will be addressed in the Joint Staff's review of the CRD:

- Does the CRD address E3?

- Does the CRD address SC and supportability?

It is noted that the *Threat* section should include the projected friendly and hostile EME, the Joint and Combined forces EME, and the potential for an EMP threat. Furthermore, E3 and spectrum supportability should be addressed in the *Capabilities Required* section of the CRD.

4.1.3 Operational Requirements Document (ORD)

4.1.3.1 General

The ORD is a formatted statement containing operational performance requirements and related operational parameters for a proposed concept or system. It is prepared by the user, or his representative, beginning with Milestone B, and updated as the program progresses. The system proposed for continued evaluation in later acquisition phases is described in an initial ORD in terms that define the system capabilities needed to satisfy the mission need. The requirements, stated as operational performance parameters, are tailored to the system type and reflect system-level performance capabilities, such as probability of kill, platform survivability, the timing of the need, and so forth. The ORD provides a bridge that links the MNS and the contract specifications. In addition, the ORD is to show linkage and the contribution to the appropriate CRD operational requirements. The ORD is to be prepared in accordance with CJCSI 3170.01 and CJCSI 6212.01.

4.1.3.2 E3/SC Considerations in ORDs

From the ORD template in CJCSI 3170.01 and CJCSI 6212.01, it is noted that both E3 and SC must be addressed. The following questions will be addressed in the Joint Staff's review of the ORD:

- Does the ORD address E3?

- Does the ORD address a requirement for spectrum supportability?

- Does the ORD identify a requirement to obtain HNA for equipment intended for operation in an overseas area of operations?

- Does the ORD address natural and man-made environmental factors, such as the EME?

- Does the ORD address the safety issues regarding HERO?

Furthermore, the *Threats* section of the ORD should include a definition of the potential hostile EME and whether the item is to survive an EMP threat. A description of the pulse can be found in MIL-STD-464 and 461. In addition, the *System Performance* section of the ORD should include a description of the natural and man-made expected EME. Furthermore, the *Capabilities Required, Other System Characteristics* section should address the safety issues regarding HERO, as well as E3 and spectrum supportability for systems and equipment.

Three sample E3/SC statements for the ORD are shown below. If afforded the opportunity, it is recommended that they be included, as applicable, as *THRESHOLD* requirements. The first applies to communications-electronics (C-E) equipment and is used to denote compliance with applicable DoD, National, and International spectrum policies and regulations. The second is to be used to require compatible operation. And, finally, the third would be used if ordnance safety is of concern.

- "<u>Spectrum Supportability and Certification.</u> All installed C-E equipment or systems, including any CI/NDI subsystems shall comply with applicable DoD, National, and International spectrum supportability policies and regulations. *(THRESHOLD)*"

- "<u>Electromagnetic Environmental Effects (E3).</u> The system or item shall be electromagnetically compatible within itself and with other systems in its operational environment. The operational performance should not be degraded by E3. *(THRESHOLD*"

- "<u>Hazards of Electromagnetic Radiation to Ordnance.</u> All ordnance items shall be integrated into the system in such a manner as to preclude all safety problems and performance degradation when exposed to its operational EME. *(THRESHOLD)*"

4.1.4 Advanced Concept Technology Demonstrations/Advanced Technology Demonstrations (ACTDs/ATDs)

ACTDs and ATDs demonstrate the performance payoffs, increased logistics or interoperability capabilities, or cost reduction potential of militarily relevant technology. ATDs are used to demonstrate the maturity and potential of advanced technologies for enhanced military operational capability or cost effectiveness, whereas ACTDs are used to determine military utility of proven technology and to develop the concept of operations that will optimize effectiveness. The results of ATDs and ACTDs are reviewed prior to making a Milestone A decision. The roles of ATDs and ACTDs in the acquisition process are described in DoDI 5000.2. E3 and spectrum supportability concerns should be addressed early in their developments. In preparing the ACTDs/ATDs, the following questions should be addressed:

- Does the ACTD/ATD address E3?

- Does the ACTD/ATD address a requirement for spectrum supportability?

- Does the ACTD/ATD address the safety issues regarding HERO, if applicable?

4.2 Program Office Tasks and Products

4.2.1 General

Today, the military faces increasingly more complex and challenging problems in developing and fielding platforms/systems or subsystems/equipment. Evolutionary acquisition strategies are the preferred approach to satisfying operational needs; however, an appropriate balance is required among key factors, such as operational needs, interoperability, supportability, and affordability of alternative acquisition solutions. Appropriate E3 requirements must be imposed to ensure a desired level of compatibility with other onboard equipment (intra-system) and within the applicable external EME (inter-system, RF, lightning, EMP, and p-static) and to address safety of personnel, ordnance, and fuel in these environments. The impact of the EME upon the operational capability of military forces, platforms/systems, and subsystems/equipment must be addressed during the acquisition process. Furthermore, there is a large increase in the use of Commercial Items and Non Development Items (CI/NDI), which are items that have already been developed and may be capable of fulfilling operational requirements either "as is" or with minor modification.

It is crucial that items be designed, built, and operated so that they are compatible with others in the operational EME. Many portions of the electromagnetic spectrum are already congested with electromagnetic-dependent items; furthermore, there is increased competition for the use of the spectrum by DoD, Government (non-DoD), and civilian users. In addition, new platforms/systems and subsystems/equipment are more complex, more sensitive, and often use higher power levels. DoD has had experience with items developed without adequately addressing E3. Performance suffered when these items were fielded, communications were disrupted, radar range was reduced, and the control of guided weapons was lost. Performance degradation can result in mission failure, damage to high-value assets, and loss of human life.

It is expected that programs will be managed in a manner consistent with the policies and principles in DoDD 5000.1, DoDI 5000.2, and DoDR 5000.2-R. In addition, programs should be in compliance with the E3/SM policies and procedures addressed in DoDR 5000.2-R, DoDD 3222.3 and 4650.1, and Office of Management and Budget (OMB) Circular A-11. This Section provides general guidance for establishing a workable and effective program to ensure that an end-item will operate in its intended EME without causing or suffering unacceptable performance degradation due to E3. In addition, guidance is provided to enable acquisition personnel to monitor programs as they progress through the acquisition process in order to ensure appropriate E3/SC considerations are addressed, including establishment of an E3/SC Working Level Integrated Product Team (WIPT) (see 4.2.2.2). Specific E3 and SC concerns are discussed in greater detail in Sections 5 and 6, respectively, of this handbook.

4.2.2 E3/SC Considerations in Integrated Product Teams (IPTs)

4.2.2.1 General

The Secretary of Defense has directed DoD to perform as many acquisition functions as possible, including oversight and review, using Integrated Product Teams (IPTs). IPTs are intended to promote teamwork by empowering their members, to the maximum extent possible, to make commitments on behalf of the organization or functional area they represent. There are two types of IPTs: Overarching IPTs (OIPTs) and WIPTs.

- OIPTs. OIPTs focus on strategic guidance, program assessments, and the resolution of issues. They provide assistance, oversight, and review as the program proceeds through the acquisition life cycle. The OIPT is composed of the Program Manager (PM), Component Staff, Joint Staff, and Office of the Secretary of Defense (OSD) staff principals involved in oversight and review of the program.

- WIPTs. WIPTs focus on particular topics such as cost, performance, test, or specific technical issues such as E3/SC. Integrating IPTs (IIPTs) are WIPTs that coordinate activities of the WIPTs and ensure that issues not formally addressed by other WIPTs are reviewed. WIPTs are advisory bodies to the PM and meet, as required, to help develop program objectives, review program documentation, and resolve program issues. WIPT responsibilities and activities can include:

    - Assisting the PM in developing strategic and program planning,
    - Assisting in the establishment of the IPT plan of action and milestones,
    - Proposing tailored document and milestone requirements,
    - Reviewing and providing inputs to documents,
    - Defining the approaches to verify requirements including analysis, modeling and simulation (M&S), and test and evaluation (T&E),
    - Establishing performance requirements,
    - Defining budget requirements,
    - Determining and assessing the feasibility of using CI/NDI, and
    - Assuming responsibility for obtaining approval from principals on issues, as well as on applicable documents or portions of documents.

For complex, multi-discipline EM issues, and for platforms/systems or major subsystems/equipment, an E3/SC WIPT, as described in 4.2.2.2, should be established. Otherwise, E3/SC expertise should be sought by program personnel to support the WIPT responsibilities listed above.

4.2.2.2 E3/SC WIPT

An E3/SC WIPT is an advisory body established by the PM to assist him in assuring that the platform/system or subsystem/equipment under development has spectrum support and will be electromagnetically compatible with itself and with the various aspects of the external EME. The E3/SC WIPT is usually comprised of both Government and contractor personnel empowered with the authority to make most decisions within their discipline while being held accountable for meeting performance and cost requirements. The team is expected to make decisions among all parties in a cooperative manner as compared to the adversarial relationships between Government and contractor personnel that often existed in the past.

An E3/SC WIPT should be established for each program that is either designated as, or meets the criteria for, ACAT I or II, or when the end-item may affect, or be affected by its intended operational EME. E3/SC WIPTs may also be established for ACAT III items when specified by the individual Services and are so designated on a case-by-case basis. The E3/SC WIPT monitors the E3/SC program associated with a project, provides assistance in formulating and implementing solutions for E3/SC problems, and establishes high-level channels of coordination. The E3/SC WIPT functions as a major resource for review, advice, and technical consultation on all aspects of the program involving E3/SC. It should be organized early in a program so that it can contribute to the trade-off studies of alternate concepts and to assess the impact of design, budgetary, and scheduling decisions related to E3/SC considerations.

4.2.2.2.1 Members

The chairman of the E3/SC WIPT operates under the authority of the PM. Often, Government and prime contractor personnel will co-chair the IPT. Membership will often vary over time depending on the status and phase of the development and the various E3-related disciplines that are deemed appropriate for a particular acquisition. E3 and SC specialists from various organizations, such as acquisition offices, modeling or test areas, and subcontractors, may be involved. Specialists in other disciplines may also need to participate such as those with contracts, safety, or system integration backgrounds. The total number of members is usually dependent upon the complexity of the program. Industry participation must be consistent with DoDR 5000.2-R.

4.2.2.2.2 Responsibilities

Responsibilities of an E3/SC WIPT should be defined in a charter. The responsibilities of an E3/SC WIPT may include the following:

- Establishing E3 performance requirements for the system or equipment, by drawing from and tailoring existing military and commercial standards,

- Defining the flow of E3/SC requirements down to elements of the system,

- Defining and updating the various aspects of the external EME,

- Defining the overall requirements verification methodology, including analysis, M&S, and T&E,

- Preparing and updating the DD Form 1494, Request for Equipment Frequency Allocation, for spectrum dependent systems and equipment,

- Defining E3/SC budget requirements,

- Providing E3/SC inputs to acquisition documents and reviewing program documentation and contract deliverables,

- Assessing ordnance (HERO), personnel (HERP), and fuel (HERF) safety issues,

- Performing E3 analyses and tests to identify potential E3/SC problems and possible solutions,

- Identifying operational limitations for E3 problems not corrected, and

- Evaluating the E3 impact of using CI/NDI on the overall performance of the end item.

4.2.2.2.3 Charter

The charter should delineate the responsibilities, objectives, membership, and operation of the E3/SC WIPT, program authority, and relationships among participants for Joint procurements. The charter should provide guidance for the WIPT to ensure that all pertinent E3/SC considerations are being implemented and to establish confidence that the platform/system or subsystem/equipment being developed can operate compatibly in its intended EME. The charter should include a purpose and scope, a description of the item being procured, its functions, intended uses, and installations. The charter should also identify the E3 disciplines that are to be addressed during the program. The charter should describe the responsibilities and role of the WIPT and its members and how its recommendations will be handled, within the overall program. If there is more than one E3/SC WIPT involved in an overall program, such as for individual subsystems/equipment and for the overall platform/system, the relationship between the WIPTs should be clearly delineated. Specific categories of representatives, such as Chairman, Vice-Chairman, Secretary, and Members, should be defined and each of their individual responsibilities and functions should be detailed. Technical specialists, contractors, and consulting members who are technical support individuals that attend only when requested should also be identified. The charter should describe in detail the activities and required schedules and milestones that should be formulated for these activities. The charter should delineate all of the documentation requirements to be provided by the WIPT. Finally, the charter should state that the WIPT will document all decisions which may later have an impact, identify essential E3 features or qualities such as special components and specialized installation techniques, and identify, as appropriate, any E3/SC deficiencies and the risks associated with them.

4.2.3 Specifying Requirements in Solicitation Documents

4.2.3.1 General

Identification or, when necessary, preparation of the applicable solicitation documents is a key part of the acquisition process. Policies and guidelines emphasize that requirements in the solicitation for hardware are to be stated in terms of performance or "what the product must do" rather than "how-to" produce the product. Specifications, Statements of Work (SOW), and Contract Data Requirements Lists (CDRLs), and Data Item Descriptions (DIDs) are documents used in solicitations that become part of a contract. It is essential that requirements be clearly articulated during the preparation of these documents. Without specific attention to clarity during the development of these documents, it becomes very difficult to evaluate proposals and to evaluate a contractor's performance after the contract has been awarded. The needs of the user should be clearly defined. The success of a procurement action relies on the contractual documents being a true and accurate statement of the user's requirements.

4.2.3.2 Performance Specifications

4.2.3.2.1 General

Preparing an end item specification is a key part of the acquisition process. As noted above, DoD policies emphasize that requirements should be stated in terms of performance or "what-is-necessary" rather than telling a contractor "how-to" perform a task. The Performance Specification is created from the ORD and should contain only performance-based requirements. It is the functional and technical description for the item being procured. It should address what the item should do, the accuracy with which it should be done, the environment that it should do it in, and the required interfaces. Contracting to a performance specification allows a contractor to become more efficient in his operations, to incorporate product enhancements, and to reduce both direct and indirect costs associated with his effort. A performance specification should state the requirements in terms of results along with criteria for verifying compliance, but without stating the methods for achieving the required results. Performance specifications give a contractor the flexibility and freedom in his design process to incorporate innovative approaches without being constrained by the specifications or contractual issues, Government oversight, and contract administration. A discussion of applicable military standards, and tailoring guidance follows in 4.2.3.2.2 through 4.2.3.2.4. (See Appendix A of this handbook for additional applicable E3 and SC documents).

4.2.3.2.2 Subsystem/Equipment Military E3 Standards

Subsystems/equipment should not be susceptible to conducted and radiated electromagnetic emissions that could degrade or render them ineffective. Likewise, they should not be sources of EMI to other equipment within the platform/system. Developmental EMI requirements for subsystems/ equipment, that is, conducted and radiated, emission and susceptibility (immunity) requirements, are defined in MIL-STD-461. Many of the requirements in the standard are universally applicable to all subsystems/equipment, regardless of end use, whereas a limited number of requirements are structured to address specific concerns associated with the end platform/system. Tables in the standard define the applicability of the requirements. The requirements contained therein are not to be applied to subassemblies of equipment such as modules or circuit cards. The requirements in the standard are to be used as a baseline and must be tailored to the specific item being procured. Verification of the EMI requirements is demonstrated by tests based on those also in MIL-STD-461. The Appendix of the standard provides rationale and guidance for implementing and tailoring the requirements contained therein. In addition, the Appendix should be consulted for detailed guidance on tailoring and performing the required tests. Compliance with the equipment/subsystem EMI requirements does not relieve the developing or integrating activity of the responsibility for providing overall platform/system compatibility.

4.2.3.2.3 Platform/System Military E3 Standards

Developmental E3 requirements for airborne, sea, space, and ground platforms/systems, including associated ordnance, are defined in MIL-STD-464. Ordnance includes weapons, rockets, explosives, electrically initiated devices (EIDs), electro-explosive devices (EEDs), squibs, flares, igniters, explosive bolts, electric primed cartridges, destructive devices, and jet-assisted take-off bottles. The standard applies to complete platforms/systems, both new and modified. The platform/system

E3 specification, although based on MIL-STD-464, must be tailored for the specific acquisition and to the expected operational environment. Verification of the tailored E3 requirements is done by test, analysis, inspection, or some combination thereof, depending upon the degree of confidence in the particular method, the technical appropriateness, associated costs, and availability of assets. The Appendix to the standard provides rationale and guidance for implementing the requirements and verification procedures contained therein. The basic requirements in MIL-STD-464 are at the platform/system level and deal with both the integration and operation of subsystems/equipment in the platform/system, and with the operation of the platform/system in its operational EME. The requirements for intra-platform/system EMC, inter-subsystem/equipment EMC, and EMV are universally applicable. Additional, specialized E3 assessments, such as lightning, p-static, HERP, HERF, HERO, and EMP, may also be required, depending on the type of item being procured, its mission, and its intended operational EME. Appendix A of this handbook should be reviewed for other possible documents that could be referenced in a specific acquisition.

4.2.3.2.4 Tailoring

E3 requirements should be tailored to the specific needs of the mission and should be considered in conjunction with program risks and costs when related to performance trade-offs. Tailoring is the process by which the requirements of a standard are adapted to the characteristics or operational requirements of an item under development. Since each platform/system or subsystem/equipment has its own requirements and characteristics, the general E3 performance requirements in MIL-STD-461 or 464, for example, may not be adequate. Quite often the requirements for items that operate in critical EME need to be made more stringent.

Tailoring involves modifying, deleting, or adding to the requirements in a basic military standard. Tailoring the requirements of a standard should either result in improved performance of the item or reduce the item's development or life cycle costs without compromising the item's operational capabilities. Tailoring the requirements of a standard does not constitute a waiver or deviation from the document. Tailored E3 performance requirements should be reflected in the solicitation documents. The depth of detail, level of effort required, and the data expected should be defined when tailoring the requirements. Subsequent tailoring of performance requirements may be requested or recommended by a contractor but should be subject to Government approval.

Tailoring is an important step in preparing the SOW, CDRLs, and the requirement documents. First, there should be an orderly process of reviewing all of the available specifications and standards and selecting those that are considered pertinent to the particular item. Then, the individual requirements from the sections and paragraphs of the selected standards, specifications, or related documents should be evaluated to determine their suitability for an item's acquisition. As required, individual requirements should be tailored for the specific application and use of the item to ensure an optimal balance between the item's operational needs and acquisition costs.

4.2.3.2.5 Examples

The following two paragraphs are examples of how to address E3 performance requirements in a subsystem/equipment specification:

- "EMI Control. The equipment shall comply with the applicable requirements of MIL-STD-461."

- "EMI Test. The equipment shall be tested in accordance with the applicable test procedures of MIL-STD-461."

As an alternative, the specific, applicable conducted emission, radiated emission, conducted susceptibility, and radiated susceptibility requirements may be specified. A system/platform specification will call out the specific, applicable, E3 requirements of MIL-STD-464 in a similar manner.

4.2.3.3 Statement of Work (SOW)

While specifications state the performance requirements for an item, the SOW establishes the work efforts that must be accomplished to successfully execute the contract and develop and produce the desired product. This document is used as an input to detailed management tools used to establish program costs and schedules. Some sample wording addressing the E3/SC area that might be included in a contract for a system is as follows:

- "The contractor shall design, develop, integrate, and qualify the system such that it meets the E3/SC performance requirements of the system specification. The contractor shall perform analyses, studies, and testing to establish E3/SC controls and features to be implemented in the design of the item. The contractor shall perform inspections, analyses, and tests, as necessary, to verify that the system meets its E3/SC performance requirements. The contractor shall prepare and update the DD Form 1494 throughout the development of the system for spectrum dependent equipment and shall perform analysis and testing to characterize the equipment, where necessary. The contractor shall establish and support an E3/SC WIPT to accomplish these tasks. MIL-HDBK-237 may be used for guidance."

4.2.3.4 Contract Data Requirements List (CDRLs)

The CDRL is the proper vehicle for describing and ordering non-hardware deliverables that result from work tasked in the SOW. The SOW should direct the performance of any non-hardware-associated work necessary to create the data used in a deliverable item, if the information is not a by-product of tests and verifications from the requirements of the specification. CDRLs are displayed on a DD Form 1423. The DD Form 1423 provides a format that can be used to tailor the details of the data being ordered to the needs of the project. A DID utilizing DD Form 1664 is used to define each item on the CDRL. DIDs establish the content required for a data product. CDRL entries other than DIDs can be tailored on the DD Form 1423 as well as the DIDs themselves. When applicable, data items should be tailored to buy only what is actually needed for a project while at the same time requiring essential efforts be performed and critical data be delivered. See 4.2.3.5 for applicable E3 and SC DIDs.

4.2.3.5 Applicable E3 Data Item Descriptions (DIDs)

DIDs are used for ordering various data products associated with hardware development. The most frequently ordered DIDs in subsystem/equipment procurements are associated with MIL-STD-461. These DIDs are

- EMI Control Procedures DID No. DI-EMCS-80199B
- EMI Test Procedures DID No. DI-EMCS-80201B
- EMI Test Report DID No. DI-EMCS-80200B

Three DIDs associated with platform/system procurements are associated with MIL-STD-464. They are:

- E3 Integration and Analysis Report DID No. DI-EMCS-81540
- E3 Verification Procedures DID No. DI-EMCS-81541
- E3 Verification Report DID No. DI-EMCS-81542

Appendix A of this handbook should also be reviewed for other possible data that may be ordered.

4.2.4 Test and Evaluation Master Plan (TEMP)

4.2.4.1 General

The TEMP documents the overall verification effort and T&E strategy of the program and identifies the necessary DT&E and OT&E activities. It relates program schedule, test management strategy and structure, and required resources to critical operational issues (COIs), critical technical parameters, key performance parameters (KPPs), and operational performance parameters derived from the ORD, evaluation criteria, and major decision points. The TEMP translates the user's requirements and capabilities essential to mission accomplishment, as stated in the ORD, into testable COIs, measures of effectiveness and performance (MOEs/MOPs), and measures of suitability. It further identifies the assets needed to perform the verification tasks, the proposed M&S efforts to be employed, the general configuration of the tests, and overall verification schedule. As noted in DoDR 5000.2-R and DoDI 4630.8, the TEMP must include at least one critical, technical parameter and one operational effectiveness issue for the evaluation of interoperability.

The mandatory format and procedures for the TEMP are provided in DoDR 5000.2-R. It is prepared for the Program Office, usually by a T&E WIPT, with E3/SC inputs from the E3/SC WIPT, and is updated as the program progresses.

4.2.4.2 E3/SC Considerations in the TEMP

The overall goals of the E3/SC portion of the test program are to ensure that E3/SC evaluations are conducted during DT&E, and that E3/SC assessments are performed during OT&E that define, for the milestone decision authority (MDA), performance and operational limitations and vulnerabilities. The TEMP identifies a tailored program of T&E tasks to demonstrate that the applicable

KPPs, critical technical parameters and COIs are met and that the platform/system or subsystem/ equipment demonstrates effective performance in its intended operational EME. See 4.3, 4.4, and 7 for additional guidance.

4.2.4.2.1 Key Performance Parameters (KPPs)

KPPs are those system capabilities or characteristics considered essential for successful mission accomplishment. Failure to meet the KPP threshold could cause the system selection to be re-evaluated or the program to be reassessed or terminated. Typically, KPPs for a given system are limited to a maximum of eight. However, in accordance with DoDR 5000.2-R, the Joint Staff must ensure that all MNSs, CRDs, and ORDs contain a specific, testable, and measurable Interoperability KPP that will be verified during DT&E and OT&E.

As such, based on the interrelationship of interoperability with E3 and spectrum supportability as shown in DoDI 4630.8, it may be practical at times to state E3 and spectrum supportability as 'Capabilities' that demonstrate the interoperability KPP. KPPs can have multiple capabilities that must be verified during DT&E and OT&E.

4.2.4.2.2 Critical Operational Issues (COIs)

COIs are derived from the ORD, the technical characteristics, and performance measures and are based on operational effectiveness, suitability, and interoperability issues. COIs are typically phrased as questions. It is unusual to have a COI dedicated to E3 or SC, but rather, there are usually a number of general ones that can be written and tailored to evaluate a number of technical areas or operational environments. Examples of such general COIs are as follows:

- "Will the platform/system (or subsystem/equipment) detect the threat in a combat environment at adequate range to allow a successful mission?" (Note: In this example, the "combat environment" includes the operational EME.)

- "Will the system be safe to operate in a combat environment?" (Note: In this example, electromagnetic radiation (EMR) hazards issues such as HERP, HERF, and HERO can be addressed, as applicable.)

- "Can the platform/system (or subsystem/equipment) accomplish its critical missions?" (Note: In this example, it can be determined if the item can function properly without degradation to or from other items in the EME.)

- "Is the platform/system (or subsystem/equipment) ready for Joint and, if applicable, Combined operations?" (Note: In this example, the item must be evaluated in the projected Joint and, if applicable, Combined operational EME.)

4.2.4.2.3 Test Limitations

Test limitations such as platform availability, test equipment, and personnel may lead towards the use of M&S for the required verification effort. The Service E3 offices and the DISA/JSC can be consulted to determine the availability of such capabilities. Also, see Appendix C of this guide for Services' test facilities and capabilities. In addition, recent reallocation of the electromagnetic spectrum from DoD and Government use to the private sector may preclude operation of the system on specific frequencies. Approved frequency allocations must be obtained for the development and procurement of the item, whereas the Service Operational Test Agency (OTA) is responsible for obtaining frequency assignments for equipment operated during operational testing.

4.2.4.2.4 Content

As noted above, content requirements for the TEMP are defined in DoDR 5000.2-R. In preparing and reviewing each part of the TEMP, the following issues and questions should be addressed:

- Under *System Introduction:*
  - Are measures of effectiveness and suitability established for E3/SC requirements that are addressed in the ORD?
  - Is E3 identified as a critical operational effectiveness and suitability parameter?
  - Are MOEs and MOPs stated and evaluation criteria and data requirements defined for COIs that include E3/SC considerations?
- Under *Integrated Test Program Summary*
  - Is the schedule for E3 verification events identified?
  - Is T&E responsibility for E3 verification established by organization?
- Under *Developmental Test and Evaluation Outline*
  - Has emission and susceptibility testing been planned for subsystems/equipment in accordance with MIL-STD-461 or commercial EMI standards, as appropriate?
  - Are E3 tests planned for CI/NDI?
  - Have platform/system E3 verifications been planned in accordance with MIL-STD-464? (Note that EMI, EMC, and EMV testing should be required for all platforms/systems, whereas special E3 T&E efforts such as HERO, HERF, HERP, EMP, lightning, and p-static may be required on a case-by-case basis, as noted in the ORD, TEMP, or contract documents.)
- Under *Operational Test and Evaluation Outline*
  - Do COIs include E3/spectrum supportability issues?
  - Have intra- and inter-subsystem/equipment E3 verifications been planned?

- Have intra-and inter-platform/system E3 verifications been planned?

- Are special E3 verifications required, depending on the results of DT&E?

- Under *Test and Evaluation Resource Summary*

  - Have adequate resources, including M&S, been identified for the following efforts?

    * Subsystem/equipment emission/susceptibility testing,
    * Testing of CI/NDI,
    * MIL-STD-464 verifications,
    * Operational Intra-platform/system EMI evaluations, and
    * Operational Inter-platform/system EMI evaluations.

4.2.5 C4I Support Plan (C4ISP)

4.2.5.1 General

The C4ISP is an acquisition document that responds to an ORD or MNS. It responds to these requirements by describing a suitable weapon or component under development, a concept of operation, and required C4I support for the item to function. The plan is to be prepared for all weapons systems or programs that interface with C4I systems. It is to include a system description, operational employment concept, derived C4I support requirements, and potential C4I support shortfalls and proposed solutions. The plan is upgraded prior to each Milestone decision. It provides the mechanism for acquisition officials to identify, coordinate, and resolve C4I supportability concerns early in the acquisition life cycle and before production and fielding of a system. The C4ISP is required by the DoDR 5000.2-R and OSD memo of 1 May 1997, *Requirements for Compliance with Reform Legislation for Information Technology Acquisitions (Including National Security Systems)*. The memo requires E3 and SM be addressed in the C4ISP at each Milestone. Content requirements for the C4ISP are defined in DoDR 5000.2-R, with additional guidance in the Defense Acquisition Deskbook.

4.2.5.2 E3/SC Considerations in the C4ISP

The following criteria will be addressed in the Joint Staff's review of the C4ISP:

- Under *C4I Support Requirements*, have the communications needs, including spectrum certification, supportability, HNA, and bandwidth requirements been identified?

- Under *C4I Support to Testing*, has the operational EME been identified to allow for realistic test and evaluation?

- Under *Potential C4I Support Shortfalls and Proposed Solutions*, has the impact of the loss of a planned command, control, or communication link as a result of an unresolved SM issue been identified?

4.3 Verification of Performance

4.3.1 General

Verification of performance requirements can be accomplished through a variety of approaches. The item should be continually assessed through the design and development process, as to whether it will satisfy its requirements. There are contractual issues that will arise regarding the specification imposed on the item. There is also a larger picture as to whether the user's needs are actually being satisfied, as demonstrated through OT&E exercises. Various tools such as inspections, analysis, M&S, testing, and evaluation all contribute to the verification effort.

Performance requirements are essentially verified through an incremental verification process. "Incremental" implies that verification of compliance with requirements is a continuing process of building an argument, or audit trail, throughout development showing that the item satisfies the imposed performance requirements. Initial engineering design must be based on analysis and models. As hardware becomes available, testing of components of the subsystem can be used to validate and supplement the analyses and models. The design evolves as better information is generated. When the system is actually produced, inspection, final testing and follow-on analyses complete the incremental verification process. It is important to note that testing is often necessary to obtain information that may not be amenable to determination by analysis. However, testing is often used to determine a few data points with respect to a particular interface requirement, with analysis and associated simulations, filling in the picture. The selection of test, analysis, inspection, or some combination thereof, to demonstrate a particular performance requirement is generally dependent on the degree of confidence in the results of the particular method, technical appropriateness, associated costs, and availability of assets. For example, verification of subsystem/equipment EMI requirements must be demonstrated by tests because analysis tools are not available which will produce credible results.

The following section discusses analysis and prediction aspects of E3/SC. Testing strategies associated with verification are addressed in detail in Section 7 of this handbook.

4.3.2 E3/SC Analyses and Predictions

4.3.2.1 General

It is essential that E3/SC analyses and predictions be employed in the planning, design, development, installation and operation of electronic subsystems/equipment and platforms/systems. These techniques are necessary to:

- Demonstrate that the required level of performance has been, or will be, achieved, and,

- To show efficient use of the frequency spectrum.

Analyses and predictions are used to identify, localize, and define potential E3/SC problems and possible solutions. They should be employed as early in a program as possible, before there are significant expenditures of time, effort, and money. E3/SC analyses are critical in identifying and resolving potential problems during development and ensuring compatibility in the operational phase of the program. The analyses provide essential information to guide the selection of appropriate courses of action to correct problems. Finally, the need for performing these analyses is closely related to the SC process as described herein.

4.3.2.2 E3/SC Analyses and Predictions Throughout the Acquisition Life Cycle

E3/SC analyses should be conducted and continually refined throughout the item's life cycle, as the operational EME is updated and as technical characteristics of the end-item become available. These analyses are typically performed at an increasing level of detail during each stage of the development life cycle. For example, early in Concept and Technology Development of a spectrum dependent subsystem/equipment, the technical feasibility of using one or more potential frequency bands and waveforms should be evaluated. The initial analysis should evaluate the suitability of alternative frequency bands and waveforms. This type of study will:

- Identify frequency bands already allocated for the type of service within the geographic areas of intended use,
- Determine the feasibility of using a proposed waveform in the allocated bands, and
- Identify issues that may enhance or preclude the ability to obtain a frequency allocation.

The E3/SC WIPT can provide specific advice on the EME to be considered in the analyses, the organizations capable of performing the analyses, schedule concerns, and required test measurements. Analyses should be conducted to determine if any of the following E3 problems are likely to be encountered:

- Within or between subsystems/equipment on a platform/system, for example, intra-platform/system or inter-subsystem/equipment problems,
- Between elements of the platform/system and elements of other platforms/systems that are likely to be operating in the same general area, such as, inter-platform/system problems, or
- Between elements of a platform/system and the EME in which they are to be operated.

These analyses usually rely on assumed or typical characteristics for the individual subsystem/equipment of a platform/system. The results from these analyses should provide the information needed to:

- Determine the most suitable frequency band(s) and subsystem/equipment parameters such as transmitter power, antenna gains, receiver sensitivity, type of modulation, rise times, information bandwidth, and so forth,
- Define E3 performance requirements, and
- Identify potential E3 problem areas and the risk involved if corrective action is not taken.

The E3 control characteristics of the proposed item should be evaluated against other existing and planned items in the EME, including natural, friendly, and hostile sources, and Joint and Combined operating forces. This will quickly identify the items operating in the EME that could cause EMI to, or could be degraded by, the proposed item. Estimated parameters and analytical techniques can be used to determine the degradation criteria. Careful application of E3 analysis and prediction techniques at the appropriate phases of an item's life cycle should ensure the required level of E3 control is defined without having either the wasteful expense of over-engineering or uncertainties of under-engineering. As the program progresses, more detailed characteristics of the item will be available. Early E3/SC analyses should be refined, based on these characteristics and the most recent EME definitions. As measured subsystem/equipment characteristics are determined, earlier analyses may be refined. Available test data for interference interactions should also be fed back into the E3 analysis. The main goal, at this time, is to resolve all potential EMI interactions. The results of this analysis will be critical for obtaining approval of the final DD Form 1494.

Additional E3/SC analyses should be performed, as required, during the Production and Deployment and Operations and Support Phases. These may be required because of:

- System modifications,
- Reported inadequate performance,
- Changing EME, or
- New mission requirements.

When a modification to an item is planned, an analysis should be performed to determine whether the modification affects the E3 characteristics of the item or others in the EME. A new EME may have to be considered; platform/system E3 requirements should be reviewed and updated, as required. If E3 is suspected as possibly causing performance degradation after an item has been fielded, then an E3 analysis may help identify the cause. Corrective action can be taken, then, to resolve the problem. If the mission requirements of the item are modified either by a new platform, additional geographic locations, and so forth, the data describing the EME must be updated. Then, an E3 analysis should be performed to determine the compatibility of the item in the new EME. Guidance throughout development is available from the E3/SC WIPT, the DISA/JSC, and the Service E3/SC points of contact noted in Appendix C.

When an item is deployed in its intended operational EME, E3 should be considered from various operational aspects such as siting effects, frequency assignment(s), effective radiated power limits, and antenna coverage. Operational inter-platform/system E3 control is generally achieved through frequency management, time-sharing, and distance separation. Usually, at this time, personnel responsible for compatible system operations should be mostly concerned with the interaction of system elements, both with each other and with elements from other systems, and less with the internal characteristics of the elements. E3 problems during operation generally involve signals that are coupled among elements of either the same or different systems.

4.3.2.3 E3/SC Analysis Process

There are a number of different applications for which E3/SC analyses are performed. The methods and procedures utilized are dependent upon the application and the results desired. In general, the analysis process to be used depends on the specific application, the accuracy and completeness of available data, and the costs to perform the analysis.

4.3.2.4 Cost of Analysis

Cost is an important factor that should be considered when selecting the specific techniques that will be used for E3/SC analyses. The costs for developing the approach, method, and procedures for E3/SC analyses, along with the manpower required to conduct the analyses, can vary considerably. The cost depends on a number of factors, including: the type of problem being addressed; the number of items involved; the accuracy and completeness of the data available; and, the need to evaluate the impact of E3 on operational performance of an item or its overall mission.

4.4 DOT&E Policy Memorandum of 25 Oct 1999

4.4.1 General

E3 has the potential to adversely impact operational performance and effectiveness of military forces, equipment, and systems. Today's complex military operational environment is also characterized by an increasingly crowded electromagnetic spectrum, coupled with a reduction of the frequency spectrum reserved for exclusive military use. Additionally, the mix of DoD systems along with CI/NDI increases the importance of effectively managing E3 and spectrum usage in the battle space. It is the responsibility of Program Offices to assure, and of OTAs to validate the readiness of systems to be fielded into this environment. Acquisition programs have traditionally evaluated E3 in narrowly scoped operational scenarios. Moreover, operational evaluations have been limited to:

- Intra-platform/system environments rather than inter-platform/system environments,

- Single Service participation in testing rather than multi-Service, or

- Single mission areas rather than multiple mission areas.

A number of Joint operations have uncovered instances of E3 problems between operational forces that resulted in restricted operational employment, impacted mission effectiveness, and even inadvertent losses suffered by friendly forces. Furthermore, peacetime deployments to host nations are failing to consider the private and commercial use of spectrum in those nations. Early operational assessments are needed to focus on these issues from the onset of the development cycle. DoD must reduce the impact of interference, avoid the cost of mitigating modifications in the field, and ensure the warfighter is cognizant of the systems' vulnerabilities and limitations in these areas.

The DOT&E policy memo is intended to more clearly define the role of OT&E in identifying potentially adverse E3 and spectrum availability situations. The policy is intended to make PMs and OTAs aware that the DOT&E plans to assess this area more systematically. This policy encompasses all aspects of E3, but emphasizes EMC/EMI and HERO. The policy memo also focuses on limitations to operational performance caused by restrictions on spectrum availability. The memo was effective immediately and applied to all DOT&E oversight programs. It was applicable to programs at the time of approval. Programs already underway were to incorporate this approach during their next TEMP approval cycle.

4.4.2 Responsibilities

The following are some of the responsibilities delineated in the DOT&E memorandum:

4.4.2.1 DOT&E Responsibilities

DOT&E will:

- Review System Threat Assessment Reports, ORDs, TEMPs, test plans, test concept briefings, and test reports to determine the adequacy of E3 testing.

- Ensure that E3 issues are satisfactorily reviewed by program acquisition IPTs.

- Review Services' evaluation approaches, including M&S, small-scale tests, and appropriate chamber and laboratory tests.

- Leverage the evaluation of E3 impacts during large-scale field training sessions.

- Review Services' early assessments to identify and understand those situations where E3 and spectrum limitations would likely affect mission accomplishment.

- Review the status of the frequency allocation process and share data with the OTAs.

- Review E3 engineering assessments and qualification test plans and results.

- As E3 issues related to fielded systems arise during OT&E or during large-scale training exercises used to complement operational tests, report these issues to the appropriate agencies for resolution.

4.4.2.2 OTA Responsibilities

OTAs are to:

- Work in conjunction with the DISA/JSC, the Defense Intelligence Agency, the system user, and others as appropriate, to conduct early independent analyses of potential E3 issues and review the resolution of these issues.

- Conduct early operational assessments that consider the intended operational EME, including storage, training, transportation, staging, and conduct of the battle in single Service, Joint, and International deployments.

- Include E3 and spectrum availability assessment issues as a standard presentation at Operational Test Readiness Reviews. These assessments should include the operational impact of any waivers and results of analyses normally accomplished as part of the DD 1494 and SC review process.

4.4.2.3 PM Responsibilities

PMs are to:

- Ensure that E3 T&E efforts receive adequate funding, and

- Ensure that E3 is sufficiently addressed in TEMPs since it will receive close scrutiny during the TEMP approval process.

4.4.3 Process

To accomplish the objectives of the policy memo, a process and a number of actions are required throughout the acquisition by DOT&E, the Program Offices, and OTAs. DOT&E, with the support of the DISA/JSC, will define OT&E E3 evaluation criteria and evaluate the testing and analyses results to define any limitations and vulnerabilities as a result of E3 and spectrum supportability problems. The information necessary to make these determinations will be gathered throughout the procurement process and should all be available prior to Milestone C. The information required to perform the OT&E E3/SC assessments is shown on Table4 of this handbook. Items 1-8 on the table are to be provided by the Program Office, whereas items 9 and 10 are the responsibility of the OTAs. As hardware becomes available, tests on components of the platform/system or subsystem/ equipment can be used to validate and supplement the analyses and models. When hardware is actually produced, inspection, testing, and follow-on analysis of potential problems previously identified complete the process. Additional guidance may be obtained from the DISA/JSC.

4.5 Commercial Items and Non-Developmental Items (CI/NDI)

Use of CI/NDI provides a cost-effective alternative to what can be a costly and time consuming design process and takes advantage of the latest technology. However, there needs to be an increased awareness of the limits associated with the use of these items in the military EME.

A commercial item is any item customarily used for non-government purposes and has:

- Been sold, leased, or licensed to the general public,

- Been offered for sale, lease, or license to the general public, or

- Evolved through advances in technology or performance and is not yet available in the commercial marketplace, but will be in time to satisfy the delivery requirements of a Government solicitation.

NDI is any item previously developed and being used exclusively for Governmental purposes by another DoD or Federal Agency, a State or local Government, or a foreign Government with which the U.S. has a mutual defense cooperation agreement.

CI/NDI should meet the basic operational requirements and function in the intended operational EME. Commercial items, NDI, and developmental acquisition programs all should address logistics support, test and evaluation, reliability, maintainability, E3, and safety issues. Furthermore, evidence of spectrum supportability and approval to operate in its intended environment, including overseas theaters, is also required for CI. From a SC standpoint, there may be a potential problem with the military using commercial equipment, particularly on commercial frequencies. A DD Form 1494 must be submitted to the military Service's frequency manager for approval. The commercial equipment procured by the military may only be operated after approval has been granted by the NTIA. On the other hand, the rules for the operation of leased CI operated by the military are different. (See Section 6 of this handbook.)

4.5.1 Policy

Federal and DoD acquisition policies dictate that all material requirements should be satisfied to the maximum extent practicable through the use of CI/NDI when such products will meet the user's needs and are cost-effective over the entire life cycle. Acquisition procedures for CI/NDI are neither new nor significantly different from established acquisition procedures. The objective is to obtain best value in meeting an item's requirements. Market research and analysis should be conducted to determine the availability and suitability of existing CI/NDI prior to the commencement of a development effort, and prior to the preparation of any product description. The desired performance requirements should be defined in terms that enable and encourage offerors of CI/NDI an opportunity to compete in any procurement to fill such requirements. CI/ NDI acquisitions require flexibility, innovation, and practical trade-offs between performance, supportability, cost, and schedule. The acquisition process should be tailored to the unique circumstances of an acquisition in order to provide the greatest benefit to the Government in terms of overall cost, product quality, timeliness of delivery, and supportability.

4.5.2 Operational Requirements

The use of CI/NDI presents a dilemma between the need for imposing E3/SC controls and the desire to take advantage of existing designs, which may have unknown or undesirable EMI characteristics. Blindly using CI/NDI carries a risk of E3 problems within the platform/system or subsystem/equipment. CI/NDI should meet the operational performance requirements for that equipment in the proposed installation. As a practical matter, the limitations of CI should be recognized. For example, CI are generally not designed to operate in the harsh military EME and in many instances lack sufficient emission control or susceptibility protection such that severe EMI can result from co-located C4I systems, other onboard electronic/electrical systems, or emitters on other platforms. Experience has shown that efforts to resolve these EMI problems may be time consuming, difficult to implement in the field and expensive for the Government, oftentimes with marginal results. Also, NDI may be designed for one environment but selected for use in another. Each potential use of CI/NDI needs to be reviewed for the actual intended usage, and a determination needs to be made of appropriate requirements for that application.

4.5.3 Assessment of CI/NDI

Since CI/NDI is already designed, it is essential that the intended EME and required E3 performance characteristics of each candidate item be assessed. Modifications required to correct E3 problems in an operational CI can be time consuming and very costly. E3 problems can present a potentially hazardous situation resulting in loss of life, damage to hardware, or degradation of mission performance capability. To mitigate the risk, an assessment should be performed to evaluate the planned EME and the equipment's EMI characteristics. This can be accomplished by reviewing existing test data, reviewing the equipment design, or with limited EMI testing. If the item was designed to a commercial standard, or to one from another Government agency, there may be existing EMI test data. That data, if available, should be reviewed to determine if the item is suitable for the particular application or intended installation. If data is non-existent, or does not allow comparison with the applicable MIL-STD-461 requirements, limited laboratory EMI testing should be performed to provide the data necessary to do the comparison. If, after evaluation of the EMI data, it is determined that the equipment would not satisfactorily operate in the intended EME, then it is the responsibility of the procuring activity to implement modifications to or to select another equipment with adequate characteristics. Be advised that there is no commercial standards equivalent to MIL-STD-461. Furthermore, evidence of spectrum supportability and approval to operate in its intended environment, including overseas theaters, is also required for CI. In other words, CI still must go through the spectrum supportability process if it is to be operated by the military.

4.5.3.1 Commercial Specifications and Standards

Not all CI/NDI will function properly in the military EME. Most commercial E3 documents are inadequate for military platforms (that is, they do not stipulate susceptibility/immunity performance requirements, do not address the concern of common-mode EMI, and so forth). Comparing miliary and commercial EMC performance requirements is a first step in determining if:

- Use of CI/NDI is practical,
- More testing is required, or
- Whether the equipment must be hardened.

4.5.3.2 Comparisons

Items successfully tested to commercial E3 requirements may meet a portion of the military E3 requirements in MIL-STD-461 or MIL-STD-464, as appropriate. Being able to compare military and commercial specifications/standards can save an appreciable amount of effort and money when qualifying CI/NDI for military applications. In order to make useful comparisons, the minimal E3 performance requirements essential for mission effectiveness should first be established by tailoring

MIL-STD-461 or MIL-STD-464 to the specific application. These E3 performance requirements should then be compared to the E3 requirements of the specifications/standards that were used to develop the CI/NDI that is being considered for procurement. When a commercial E3 requirement is equivalent to, or more stringent than, a MIL-STD-461 or 464 tailored requirement, it can be assumed the CI/NDI satisfies the military E3 performance requirement. If there is no equivalent commercial E3 requirement, testing in accordance with MIL-STD-461 or 464 should be conducted to demonstrate whether the CI/NDI E3 performance is in compliance with the established performance requirements. Information to assist in comparing major National and International commercial EMC standards with MIL-STD-461E is provided as Appendix D of this handbook and in the detailed report EPS-0178.

4.5.3.3 Alternatives

Several alternatives exist when E3 assessments or the testing of CI/NDI demonstrates that the equipment or system cannot meet its E3 performance requirements. These include:

- Shielding or isolation of the item,
- Frequency management,
- Filtering,
- Blanking,
- Reassessing the existing mission profiles to determine if the CI/NDI E3 performance is acceptable, or
- Abandoning the CI/NDI acquisition strategy when the E3 parameters of available CI/NDI are far inferior to the requirement.

4.6 Matrices of E3/SC Tasks and Applicable Documents

Table 1 shows the checkpoints during the acquisition life cycle where E3/SC requirements and issues can be reviewed.

Tables 2 through 4 provide guidance and checklists to ensure that E3/SC are adequately considered as the program progresses through the acquisition process. A checklist is presented for each milestone decision point. If the source document does not provide the necessary information, the issues should be raised at appropriate forums, such as IPT meetings, to obtain the required information.

Table 5 contains a list of tasks normally required for most acquisitions and a list of applicable documents that address each task. Additional Service-unique publications may also be consulted. See Appendix A for a list of other such publications.

Acquisition Phases	Concept and Technology Development	System Development and Demonstration	Production and Deployment	Operations and Support
Decision Points	◆ MS A	◆ MS B	◆ MS C	
Documents Requiring E3/SC Input				
MNS ▽	▽			
CRD. ORD. C4ISP	▽	▽		
TEMP	▽	▽		
Minimum DD Form 1494 Submittals	▽	▽		
E3/SC Testing Opportunities				
DT&E		▽ Prototype	▽ EDM ▽ FAAT ▽ LRIP	
OT&E		▽ Prototype	▽ EDM	▽ LRIP ▽ As required

Commercial Item

TABLE 1. E3/SC Checkpoints.

Legend:

EMD: Engineering Development Model
FAAT: First Article Acceptance Test
LRIP: Low Rate Initial Production
MS: Milestone

TABLE 2. Milestone A (Concept and Technology Development Approval) Data Requirement Checklist.

Objective: To ensure that E3 and SC are addressed in requirement documents.

Required Information:

1. DD Form 1494 submitted to Service Frequency Management Office

2. MNS that addresses the following:

   a. Description of operational EME (that is, the operational environment, theater, mission in the operational plan (OPLAN), and so forth) in which the item must operate, and

   b. Compliance with applicable DoD, National, and International SM policies and regulations

TABLE 3. Milestone B (System Development and Demonstration Approval) Data Requirements Checklist.

Objective: To ensure that E3 and SC issues are identified and adequately addressed.

Required Information:

1. DD Form 1494 submitted to Service Frequency Management Office

2. Status of HNA efforts

3. ORD that addresses the following:

   a. Description of operational EME (that is, the operational environment, theater, mission in the OPLAN, and so forth),

   b. Compliance with applicable DoD, National, and International SM policies and regulations,

   c. Intra- and inter-platform/system EMC, and

   d. E3 specialty issues (HERO, HERP, HERF, EMP, lightning, and p-static, as appropriate).

4. TEMP, which has E3 within the scope of a COI, a list of verification efforts that addresses effectiveness/suitability/survivability of the platform/system or subsystem/equipment in the intended operational EME¸ and provisions for testing CI/NDI

5. E3 and SM potential risks identified and tests and analyses performed to date which identify and define operational limitations and vulnerabilities

NOTE: All acquisition documents should contain requirements for E3 and SC tests and analyses.

TABLE 4. Milestone C (Production and Deployment Approval) Data Requirements/OT&E E3/SM Assessment Checklist.

Objective: To identify to the best extent possible E3/SM limitations and vulnerabilities.

Required Information, as appropriate:

1. DD Form 1494 submitted to Service Frequency Management Office

2. Status of HNA effort

3. Description of operational EME (that is, the operational environment, theater, mission in the OPLAN, and so forth)

4. Latest program documentation (MNS, CRD, ORD, C4ISP, performance specification, SOW).

5. TEMP which contains:

    a. E3 within the scope of a COI, and

    b. List of tests and analyses used to determine the item's effectiveness/suitability/survivability in the operational EME

6. Copies of the following verification results, including T&E data:

    a. Intra-platform/system data, including:

        (1) Antenna coupling and blockage analyses and/or test data,
        (2) Subsystem/equipment EMC analyses and/or test data, and
        (3) CI/NDI EMC analyses and/or test data

    b. Inter-platform/system EMC verification results and test data for spectrum dependent (Joint E3 Evaluation Tool (JEET) model) and non-spectrum dependent equipment

    c. Special E3 analyses and/or test data (HERO, HERP, HERF, EMP, lightning, and p-static) if required by the ORD, TEMP, or contractual documents

7. E3 and SM impact assessments which identify and define operational limitations and vulnerabilities, including lessons learned

8. DT&E test plans and results/reports

9. Initial operational test and evaluation (IOT&E) test plans and results/reports

10. User initiated test results

TABLE 5. E3/SC Tasks and Applicable Documents.

E3/SC TASKS	DoDD 4630.5	DoDI 4630.8	DoDD 4650.1	DoDR 5000.2-R	DoDD 3222.3	CJCSI 3170.01	CJCSI 6212.01	MIL-STD-461	MIL-STD-464	MIL-STD-469	MIL-HDBK-235	MIL-HDBK-237	MIL-HDBK-253	SD-2	SD-16	NTIA Manual
Prepare E3/SC inputs to MNS, ORD, CRD, C4ISP, and TEMP	X	X		X		X	X					X			X	
Organize E3/SC WIPT				X	X							X				
Determine spectrum requirements and submit requests for frequency allocation (DD Form 1494) at appropriate times			X	X	X					X		X				X
Define EME which may be encountered during life cycle and update								X	X		X	X				
Determine feasibility and evaluate possible use of CI/NDI				X	X			X	X			X		X		
Verify if performance of proposed item is compatible in its intended operational EME	X	X		X	X			X	X	X	X	X	X			
Define acceptable performance criteria	X	X						X	X	X		X				X
Evaluate E3 standards, predicted EME, and acceptable performance criteria to determine if item will meet general E3 and spectrum supportability criteria	X	X						X	X	X	X	X				X
Establish initial E3 requirements for inclusion in performance specification, SOW, CDRL								X	X	X	X	X				X
Specify DT&E and OT&E requirements to demonstrate the item will perform its mission in the intended EME; include in TEMP				X	X			X	X	X		X			X	X
Review all contractor data items								X	X	X		X				X
Perform special E3 tests and/or analyses as specified in TEMP				X	X			X	X	X		X				X
Define vulnerabilities and limitations due to E3/SC issues				X	X			X	X	X		X				
Request assignment of test frequencies			X	X	X							X				
Monitor and review waiver requests and modifications					X							X				X
Investigate and fix operational E3 problems					X							X				

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5. E3 CONCERNS

5.1 Electromagnetic Environment (EME)

5.1.1 General

The EME is the resulting product of the power and time distribution, within various frequency ranges, and includes the radiated and conducted electromagnetic emission levels that may be encountered. It is the totality of electromagnetic energy, from man made and natural sources, to which a platform/system, or subsystem/equipment will be exposed within any domain (that is, land, air, space, sea) while performing its intended mission throughout its operational life cycle. When defined, the EME will be for a particular time and place. Specific equipment characteristics (such as operating frequencies, emitter power levels, and receiver sensitivity), operational factors (such as distances between items and force structure), and frequency coordination all contribute to the EME. In addition, transient emissions and their associated rise and fall times (such as from EMP, lightning, and p-static) also contribute.

One of DoD's basic objectives is to ensure that all military subsystems/equipment and platforms/ systems are self-compatible and not adversely affected by the operational EME. Undesired electromagnetic energy may degrade the performance of an item temporarily, in which case the item may operate in a degraded mode when sufficient electromagnetic energy is present. Alternatively, the electromagnetic energy may cause permanent damage, in which case the item will not operate until it is either repaired or replaced and the E3 problem has been resolved. Examples of the effects that can be caused by undesired electromagnetic energy, depending on the victim, are:

- Burnout or voltage breakdown of components, antennas, and so forth,
- Performance degradation of receiver signal processing circuits,
- Erroneous or inadvertent operation of electromechanical equipment, electronic circuits, components, ordnance, and so forth,
- Unintentional detonation or ignition of ordnance and flammable materials, and
- Personnel injuries.

5.1.2 EME Effects

The effects of undesired electromagnetic energy on a platform/system or subsystem/equipment operating in a specific environment are dependent upon the item's susceptibility or immunity, characteristics, and the amplitude, frequency, and time-dependent characteristics of the EME. To prevent E3 problems from occurring, the possible effects of undesired electromagnetic energy should be considered for each item when operating in its intended EME. Furthermore, compliance with the National Environmental Policy Act requires Environmental Impact assessments for many types of systems and installations. These assessments must address the potential impact of the

EME on personnel, ordnance and fueling areas. As discussed earlier in this handbook, a requirement to demonstrate satisfactory performance in a defined EME should be included in all procurement documentation and addressed in the TEMP.

5.1.3 Contributors to the EME

The EME in which military platforms/systems and subsystems/equipment must operate is comprised of a multitude of natural and manmade sources. Natural sources consist of:

- Galactic noise,
- Atmospheric noise,
- Solar noise,
- P-static,
- Lightning, and
- ESD.

Manmade sources consist of friendly and hostile emitters, both intentional and unintentional, and spurious emissions such as motor noise and intermodulation products. Intentional emitters include, but are not limited to the following types of subsystems/equipment:

- Communications,
- Navigation,
- Meteorology,
- Radar,
- Weapon, and
- Electronic Warfare (EW).

Unintentional emitters encompass any item that uses, transforms, or generates any form of electromagnetic energy. Therefore, any electrical, electronic, electromechanical, or electro-optic device can be an unintentional emitter. Examples of unintentional emitters include the following:

- Intentional radiators emitting other than the intended emission,
- Computers and associated peripherals,
- Televisions, cameras, and video equipment,

- Microwave ovens,

- Radio and radar receivers,

- Power supplies and frequency converters,

- Motors and generators, and

- Electrical hand tools.

Power levels and source locations relative to the item are the two main considerations used for determining which sources are the dominant contributors to the operational EME. For example, during normal, non-combat operations the primary sources of electromagnetic energy would be from own and nearby unit's transmissions and spurious emissions. In a combat scenario, enemy transmissions could be another major contributor. Hence, the EME within which an item must operate and survive is both mission-dependent and scenario-dependent.

5.1.4 Defining the EME

The EME in which the item is most likely to operate must be defined early in the acquisition process. The initial step is to identify the major geographic regions in which the system will operate, that is, the U.S., Atlantic, Pacific, Europe, Middle East, or possibly, worldwide. The next step is to identify the specific countries in each major region in which the item is likely to be deployed, since obtaining a frequency allocation may be more challenging in some countries. Once that is done, the theater and missions must be defined. Finally, the individual host platforms/systems on or near the item to be deployed, must be identified.

Once the geographic areas and host platforms have been determined, the types and characteristics of any spectrum dependent item present or planned that could possibly interact with the proposed item should be identified. This identification addresses both items affected by and those that affect the item. The identification must address both the military and commercial EME alike. The information on interacting items will be used as an initial input for frequency allocation and E3 analyses. Although the EME is defined early in the program, continuous update of the EME is necessary throughout the entire life cycle because the environment is not static. Other entities (friendly and hostile) will be simultaneously developing or fielding items that will operate within the same EME. Data concerning these "new" items must be sought out and added to the EME definitions. In addition, the original mission requirements of the proposed item may be changed, forcing additional geographic regions, countries, host platforms, and nearby equipment to be considered. As EME definitions are updated, they should be used to refine E3 analyses and frequency allocation requests. MIL-HDBK-235 and MIL-STD-464 describe various land-based, ship-based, airborne, and battle space environments, including friendly and hostile EME levels that may be encountered by an item during its life cycle. One of the difficulties encountered when specifying the performance requirements of an item is that, in many cases, the characteristics of the intended operational EME are quantitatively unknown. The following factors should be considered when defining the anticipated operational EME of an item.

5.1.4.1 EME Profile

Each item, in all likelihood, will be exposed to several different EME levels during its life cycle. MIL-HDBK-235 and MIL-STD-464 provide general information on the EME. Referring to these documents can be useful when defining the power levels of the EME to which an item may be exposed. However, the tables should be tailored for specific applications. Specifying an EME level that is too stringent may result in additional costs that are unnecessary. Each distinctive EME that an item will be exposed to during its life cycle should be defined before specifying its performance requirements. For example, a missile will be exposed to different EME levels during shipment, storage, checkout, launch, and the approach to a target. The specified E3 control performance requirements should ensure the item's performance is not affected by any of the EME levels that will be encountered.

5.1.4.2 Configuration

The physical configuration of an item may vary depending on its intended location. An item's immunity or susceptibility to the EME may also vary depending on its physical configuration and location relative to the intended operational EME. Therefore, when developing E3 performance requirements, both the physical configuration and the location of the item within each of its intended operational EME should be considered.

5.1.4.3 Operational versus Survivability EME

There is usually a significant difference between the levels of electromagnetic energy that will temporarily degrade or limit the effective performance of an item (operational) and those levels that will permanently damage an item (survivability). The requirement to control any effects from the EME under all circumstances should be, by necessity, more stringent than just to ensure that the item will not be permanently damaged. When specifying E3 control requirements, the item's function and how critical it is to the intended mission should be taken into account. There are also precautions that can be taken to protect equipment from being permanently damaged by electromagnetic energy when not in use that cannot be implemented when they are in an operational mode.

5.1.4.4 Susceptibility

The susceptibility characteristics of an item are dependent upon its design characteristics. For example, the item may respond to a broad frequency range or be frequency selective. Also, some victims have response times in microseconds and are affected by the peak power levels of short-term signals, whereas other victims are affected by heating and respond more slowly to the average power levels of signals. The design characteristics of an item, as well as the shielding integrity, choice of components, and use of filtering should be considered when evaluating the effect the EME has on an item.

5.1.4.5 Future Considerations

Possible changes in the intended operational EME and future applications of an item also should be considered when defining the EME that an item may encounter. An item designed to operate in a specific EME may, in the future, be required to operate in another, or used to perform functions and missions that were not planned for when the item was originally designed. Although the cost of an item may increase when designed for an EME that is more severe than the EME that is currently being predicted to be encountered by the item, the increase in cost may be justified in terms of adaptability for future applications. This is particularly true for items designed by a Service that may, ultimately, be used in a Joint operation.

5.1.4.6 Conditions Precluding EME Exposure

When defining the operational EME that an item will be required to operate or survive in during its life cycle, operational and installation conditions that can preclude or reduce exposure to the EME and any added information that may affect an item's exposure to the EME should be considered. For example, the complement of emitters on a platform or site will provide an indication of the frequency bands within which high levels of electromagnetic energy will probably be encountered. Dimensional restrictions and intervening structures may exist that cause an item to operate in the near or induction field region of an antenna. Other factors such as the platform usage on which an item is in-stalled and the operational use of the item also should be considered.

5.2 EMC

EMC is the capability of systems, equipment, and devices to operate in their intended operational environment within a defined margin of safety and at designed levels of performance without suffering or causing unintentional degradation because of EMI. It involves the application of sound electromagnetic spectrum management; platform/system and subsystem/equipment design considerations that ensure EMI-free operation; and clear concepts and doctrines that maximize operational effectiveness. It is apparent, then, that the lack of EMC due to the presence of EMI is the concern.

The threat presented by RF emitters around the world is becoming increasingly more hostile. Increased multi-National military operations, proliferation of both friendly and hostile weapons systems, and the expanded use of the spectrum worldwide have resulted in an operational EME not previously encountered. Therefore, it is essential that these environments be defined and used to establish system E3 requirements. Documents such as MIL-HDBK-235 and MIL-STD-464 list various land-based, ship-based, airborne, and battle force emitters and associated environments. The electromagnetic fields from these emitters, which may illuminate platforms/systems, are very high and can degrade overall performance if they are not properly addressed. Operational problems resulting from the adverse effects of electromagnetic energy on systems/platforms are well documented. Problems include premature detonation, loss of communications, loss of guidance and tracking radar, component failure, and unreliable built-in-test indications. These problems underscore the importance of designing platforms/systems that are compatible with their intended operational EME. Joint operations further increase the potential for safety and reliability problems since the system is likely to be exposed to an operational EME different from that for which they were designed.

5.3 EMI

EMI is any electromagnetic disturbance, whether intentional, as in some forms of EW, or unintentional as a result of unintended or spurious emissions, intermodulation products, and the like, that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronic or electrical equipment. Related to EMI is “electromagnetic susceptibility” which is the inability of an item to perform its function without degradation while in the presence of an electromagnetic disturbance.

The EMI characteristics (emission and susceptibility) of individual equipment and subsystems must be controlled to obtain a high degree of assurance that these items will function in their intended installations without unintentional electromagnetic interactions with other equipment, subsystems, or the external EME. The EME within a system is complex and variable depending upon the operating modes and frequencies of the onboard equipment. Also, configurations are continuously changing as new or upgraded equipment are installed. Furthermore, items developed for one platform may be used for other platforms. MIL-STD-461 provides a standardized set of EMI control and test requirements that form a common basis for assessing the EMI characteristics of subsystems and equipment. Adherence to these EMI requirements will afford a high degree of confidence that the item will operate compatibly upon integration and would minimize potential cost impact and scheduling delays. A further concern is the need for equipment using power to control transients to levels that will not cause upset or damage to other power users.

5.4 EMP

An EMP is the electromagnetic radiation (EMR) from a nuclear explosion caused by Compton-recoil electrons and photoelectrons from photons scattered in the materials of the nuclear device or in a surrounding medium. The resulting electric and magnetic fields may couple with electrical or electronic systems to produce damaging current and voltage surges. EMP may also be caused by non-nuclear means. A nuclear burst above the atmosphere that produces coverage over a large area is called a high-altitude EMP, or HEMP.

In a nuclear conflict, it is possible that many military systems will be exposed to an EMP. The resultant EM field is characterized by high amplitude, short duration, and short rise time pulse for a very brief time. There are two types of EMP, each distinguished by the height of the burst. One type is exo-atmospheric where the detonation is outside of the atmosphere but which can produce coverage over large geographical areas; and the other is endo-atmospheric which results from a low altitude detonation. In either case, the effects can be detrimental to the performance of many electrical and electronic military systems. MIL-STD-2169, a classified document, provides detailed descriptions of the threat waveforms. These threats are converted to unclassified requirements in MIL-STD-461 and 464.

5.5 Electromagnetic Radiation (EMR) Hazards (RADHAZ)

EMR can have harmful effects on personnel, fuels, and ordnance if uncontrolled. These effects are discussed below.

5.5.1 HERP

A potential hazard can exist when personnel are exposed to an electromagnetic field of sufficient intensity to heat the human body. The fact that heating is associated with absorption of RF power by humans was known nearly 50 years ago and led to the introduction of RF diathermy for medical and surgical purposes. The heat resulting from RF field interactions simply adds to the metabolic heat load of the human. If the body's heat gain exceeds its ability to rid itself of excess heat, the body temperature rises. Therefore, if significant power is absorbed, an increase in body temperature can occur that could have a competing effect on metabolic processes, with potentially deleterious effects. Radar and EW systems present the greatest potential for personnel hazard due to their high transmitter output powers and antenna characteristics. Personnel assigned to repair, maintenance, and test facilities have a higher potential for being overexposed because of the variety of tasks, the proximity to radiating elements, and the pressures for rapid maintenance response. Safety tolerance levels for exposure to EMR are defined in DoDI 6055.11.

5.5.2 HERF

An electromagnetic field of sufficient intensity can create sparks with sufficient energy to ignite volatile combustibles, such as fuel. For fuel vapors to ignite, a flammable fuel-air mixture must be present, in addition to an intense electromagnetic field. EMR can induce currents into any metal object. The amount of current, and thus the strength of a spark across a gap between two conductors, depends on the field intensity of the energy and how well the conductors act as a receiving antenna. Many parts of a system, a refueling vehicle, or a static grounding conductor can act as receiving antennas. The induced current depends, mainly, on the conductor length in relation to the wavelength of the RF energy and the orientation of the field. It is neither feasible to predict nor control these factors. The hazard criteria must then be based on the assumption that an ideal receiving antenna could be inadvertently created with the required spark gap. The existence and extent of a fuel hazard are determined by comparing the actual RF power density to an established safety criterion. T.O. 31Z-10-4 and OP 3565 provide procedures for establishing safe operating distances.

5.5.3 HERO

The potential exists for munitions or EEDs to be adversely affected by EMR. EEDs include all components required to control, monitor, or initiate an EID in ordnance. Ordnance includes weapons, rockets, explosives, EIDs themselves, squibs, flares, igniters, explosive bolts, electric primed cartridges, destructive devices, and jet-assisted take-off bottles.

Modern communication and radar transmitters can produce a high EME that can be hazardous to ordnance. These environments can cause premature actuation of ordnance. RF energy of sufficient magnitude to fire or dud EIDs can be coupled from the external EME, either by explosive subsystem wiring or by capacitive coupling from nearby radiated objects. Possible consequences include both hazards to safety and performance degradation. EIDs should be selected to be the least sensitive that will meet system requirements. Each EID must be categorized as to whether its inadvertent ignition would lead to either safety or performance degradation problems. The Program Office should determine this categorization. OD 30393 provides design principles and practices for controlling EMR hazards to ordnance. MIL-STD-1576 provides guidance on the use and test of ordnance devices in space and launch vehicles.

5.6 EMV

EMV is the characteristic of a system or equipment that causes it to suffer degradation in performance, or the inability to perform its specified task, as a result of the operational EME. A platform/ system or subsystem/equipment is said to be vulnerable if its performance is degraded below a satisfactory level because of exposure to the stress of an operational EME or transient. There are many different EME levels that an item will be exposed to during its life cycle. Many threats will be seen only infrequently. However, if the item encounters an operational EME corresponding to its susceptibility characteristics as observed in a laboratory test, it may suffer degradation in performance, or not be able to perform its specified task at all in that operational environment. An EMV analysis is usually required to determine the impact of a laboratory-observed susceptibility on actual operational performance. The results of the EMV analysis guide the possible need for hardware modification, additional analyses, or testing.

5.7 Electronic Protection (EP)

EP is an element of EW involving actions taken to protect personnel, facilities, and equipment from any effects of friendly or enemy employment of EW that degrade, neutralize, or destroy friendly combat capability. It involves both passive measures, like the use of emission control (EMCON) measures to reduce interception of friendly signals by the enemy, and active measures, such as increasing transmitter power or using electronic counter-countermeasure circuits in receivers to overcome the effects of jamming. As it relates to E3, EP is the control of intentional and unintentional radiated emissions, in excess of the EMCON limits, from a receiver or an active transmitter to reduce the probability of detection, classification, and identification of the active transmitter or receiver.

Intentional and unintentional radiated emissions can compromise a system's location and identity if the enemy can detect and analyze these emissions. This could lead to degradation, neutralization, or destruction of friendly combat capability. EMCON procedures can be used to deny exploitation by threat forces, however, these procedures can not always prudently be deployed. Requirements on the level of emissions radiated during EMCON are included in MIL-STD-464. The standard also includes EP requirements for emissions in excess of the EMCON limits.

5.8 Lightning

There is no doubt that lightning can be hazardous to systems and equipment and that items must include provisions for lightning protection. There is no known technology to prevent lightning strikes from occurring; however, lightning effects can be minimized with appropriate design techniques. Lightning effects can be divided into direct (physical) and indirect (electromagnetic) effects.

- Direct effects of lightning are any physical damage to the system structure or equipment due to the direct attachment of the lightning channel. These effects include tearing, bending, burning, vaporization, or blasting of hardware, as well as the high-pressure shock waves and magnetic forces produced by the associated high currents.

- Indirect effects are those resulting from electrical transients induced in electrical circuits due to coupling of the electromagnetic fields associated with lightning and the interaction of these electromagnetic fields with equipment in the system.

In some cases, both direct and indirect effects may occur to the same component. For example, a lightning strike to an antenna could physically damage the antenna and send damaging voltages into the transmitter or receiver connected to that antenna. Also, currents and voltages conducted by mechanical control cables or wiring in aircraft may cause serious electrical shock. DOT/FAA/CT-89/2 contains electrical lightning characteristics and design guidance.

5.9 Precipitation Static

P-static is an electromagnetic disturbance caused by a random electrostatic discharge buildup as a result of the flow of air, moisture, or airborne particles over the structure or components of a vehicle moving in the atmosphere, such as an aircraft or spacecraft. As systems in motion encounter dust, rain, snow, and ice, an electrostatic charge builds up. This buildup of static electricity causes significant voltages to be present which can result in interference to equipment and constitute a shock hazard to personnel. For aircraft applications, air crew personnel may be affected during flight, and ground personnel may be affected after landing. P-static deserves special emphasis because of increased sensitivity of electronic equipment, wider frequency spectrum for new communications systems, and increased use of composite materials.

5.10 Spectrum Supportability

Spectrum supportability is the assurance that the necessary frequencies and bandwidth are available to systems used by the military in order to maintain effective interoperability in the operational EME. It includes SC, HNA, and EMC. The availability of adequate spectrum to support military electronic systems and equipment is critical to maximizing mission effectiveness. Spectrum planning and frequency management must be given appropriate and timely consideration during the development, procurement, and deployment of military assets that utilize the electromagnetic spectrum. To ensure maximum EMC among the various worldwide users of the spectrum, it is essential that antenna-connected equipment and other intentional radiators, such as identification devices and stock control micro strips, comply with spectrum usage and management requirements. DoD's use of the spectrum is constantly being challenged by the commercial sector. As more and more spectrum is taken away, the available spectrum must be managed as efficiently as possible to ensure the success of all military operations. Elements of spectrum supportability are:

- <u>Frequency Allocation</u>. The designation of frequency bands for use by one or more radio communication service, for example, fixed, land mobile, air-to-ground, or commercial broadcast. (based on National and International agreements).

- <u>Frequency Assignment.</u> The authorization for a spectrum-dependent system to use a frequency under specified conditions or restrictions. (license to operate).

- <u>Spectrum Certification (SC).</u> The process by which development or procurement of a C-E or spectrum dependent, system or equipment, including all systems employing satellite techniques, will be reviewed and certified for compliance with spectrum management policy, allocations, regulations, and technical standards to ensure that RF spectrum is available (based on National and International regulatory allocation requirements). See Section 6 of this handbook for a discussion of the SC process.

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6. SPECTRUM CERTIFICATION

6.1 General

Spectrum supportability must be given appropriate and timely consideration in acquisition planning, development, procurement, and deployment of spectrum dependent systems or equipment. A DD Form 1494 must be submitted to the appropriate Service coordinator in accordance with the requirements and procedures of DoDD 4650.1, DoDI 5000.2, and the form itself. SC establishes the basis to ensure that DoD systems utilizing the spectrum are capable of operating in their intended environment without causing or suffering unacceptable degradation of performance due to EMI. The process involves efforts required to obtain an approved frequency allocation and HNA, where applicable.

The data required, and provided, on DD Form 1494 includes identification of the item, requested spectrum support (operational frequency band(s)), planned deployment information, equipment technical characteristics, and performance data. This data, maintained at the DISA/JSC, benefits that portion of the SM community involved in mission planning for DoD warfare and training operations. SC data enables:

- Frequency assignments for DoD operations, exercises, and training,
- Mitigation or resolution of EMI problems,
- Siting of new DoD or commercial systems on ships, aircraft, in space, and at shore sites,
- Integration of CI into the intense EME found on military platforms and installations,
- Establishment of mutually beneficial parameters for spectrum sharing with Industry, and
- Coordination with foreign (host) nations for use of DoD systems overseas.

Spectrum supportability must be addressed early in the conceptual phase of system development and is periodically reviewed and updated throughout the system design. OMB Circular A-11 requires that spectrum support be obtained before submitting funding estimates for the development or procurement of systems or equipment. In addition, certification is required before funds are obligated for spectrum dependent systems or equipment.

6.2 Issues

6.2.1 Threats to DoD Spectrum Access

Use of the spectrum by DoD is expanding based on emerging advanced technologies and Joint warfighting strategies. The DoD employs a large number of weapon systems in executing military missions, and most, if not all, depend upon the electromagnetic spectrum. Loss of spectrum access, however, has the potential to derail efforts to exploit available technology. DoD is provided access to spectrum by the Federal Government and shares spectrum with other Federal

Agencies, local Governments and private Industry. Consequently, the DoD must demonstrate critical needs to maintain specific portions of the spectrum for exclusive military use. This is truer now more than ever before considering the wide use of new wireless technologies in the marketplace. Expanding commercial access to spectrum is a reality today. In many cases, spectrum use is bound by International agreements since DoD operations are conducted worldwide, bringing new challenges to efforts involved in planning and coordinating Joint missions. Relocation of systems to new bands is difficult and costly because an equipment may interact with many others. In addition to the increased likelihood of operational EMI because of overcrowding in the remaining spectrum, equipment redesign, additional T&E , re-certification for spectrum use, and training all may be necessary. Further domino effects are also likely, forcing changes to other parts of the integrated military system. Many frequencies used by DoD are those that work best for the intended purpose, dictated by the laws of physics. DoD efforts to safeguard needed spectrum access depend on the capability to demonstrate the criticality of targeted frequencies. The acquisition community plays a key role since the spectrum certification process provides much of the information needed to substantiate DoD positions.

6.2.2 Joint Missions and Host Nation Agreements

The International Telecommunication Union (ITU), an approximately 200-nation member organization, regulates the RF spectrum worldwide and promotes International cooperation in the efficient use of the spectrum. In ever-increasing global competition for limited frequency spectrum, the DoD must provide for mutual compatibility and agreement regarding its use in the International community. Spectrum is a national resource managed by each country. Granting approval to DoD assets to transmit within a country is resolved at the sole discretion of that country, based on the perceived potential for EMI to local receivers. Use of military or commercial C4I systems in host nations requires coordination and negotiation including approvals and certifications. Host nations have denied frequency assignments to DoD systems because of EMI caused to in-country telecommunication systems. These may be, for example, cellular and other mobile phones, civil aviation, civil defense, other civil and Government systems, meteorological sensors, radar, military systems, and satellite communications.

The Military Departments conduct operations in territories of Governments other than the U.S. In such situations, use of the spectrum for U.S. operations is by permission of the host Government and is formalized in an agreement between the U.S. and that Government. To ensure EMC, the host Government in most cases requires the U.S. to supply data concerning the equipment characteristics from a spectrum usage standpoint. The data required in most of these situations are the same data elements required in DD Form 1494. Failure to obtain HNA can result in action as severe as confiscation of the equipment. As a minimum, such equipment will not be allowed to operate.

Submission of the DD Form 1494 is the key to obtaining HNA. This form is forwarded to the Unified Commands where the system will be deployed overseas. Each Unified Command Joint Frequency Management Office (FMO) then reviews, coordinates, and obtains HNA of specified frequencies for the system. Once approval has been obtained, the Unified Command must request assignment of a specific frequency, or frequencies, from the host nation to operate the equipment. As indicated in 6.2.3, use of CI in DoD operations overseas must also be coordinated through these negotiations.

6.2.3 Spectrum Certification of CI

As noted earlier in this document, procurement and use of CI in DoD is encouraged as an alternative to the costly in-house development process. However, the civilian spectrum is generally not authorized for military use. When contracting for the acquisition of spectrum dependent CI, particularly those that utilize civilian frequencies, it is essential that SC considerations be addressed, in addition to the E3 issues discussed elsewhere in this handbook. DoD directives, instructions, and regulations all require acquisition personnel to obtain SC approval for all spectrum dependent equipment, including CI emitters and receivers, particularly where the Government relies on commercially provided services or secondary allocations, that is, permission to use on a not-to-interfere basis for military purposes. This requirement extends to CI used for military purposes, whether operating in Government exclusive bands, shared bands, or non-Government exclusive frequency bands. Government requirements for use of the spectrum in exclusive non-Government bands can be accommodated either by:

- Becoming a user of a commercial service, such as cellular telephone, or

- Obtaining a secondary allocation.

When using a commercial service, a Government user will buy or lease CI equipment that has been “Type-Accepted” in accordance with Federal Communications Commission (FCC) rules. As a practical matter, and as discussed in 4.5.2, the limitations of CI and their potential for EMI problems should be recognized. The FCC requirements differ markedly from those imposed by the DoD and, generally, do not provide the necessary data on equipment technical characteristics or system performance. This data is important to the SM community, and is used for frequency planning of Joint missions and training, EMI resolution efforts, HNA, and other related tasks. Secondary allocations can be even more of a problem for the Government user who, in this case, is afforded no protection at all from EMI. Furthermore, regulatory policy stipulates that primary allocation operations will receive no EMI from secondary users. Consequently, operational EMI can be expected in the absence of appropriate SC considerations applied during system acquisition.

CI generally enters the SC process prior to Milestone C since the development has already taken place. In these cases, equipment manufacturers must supply the requisite technical characteristics and performance data needed to complete the process for the following reasons:

- The potential for EMI is increased, because most CI are not designed or tested for operation in the extremely dense, high power EME found on DoD platforms and in mission battle space situations. Conversely, the resolution of such problems is made considerably more difficult when SC data is not available for use in developing potential fixes.

- Site planning, for installing CI systems in DoD platforms, while maintaining mutual compatibility between installed systems, becomes extremely difficult, if not impossible to do efficiently in the absence of specific, spectrum performance data.

- CI with unknown, out-of-band emission characteristics can inadvertently cause severe EMI to critical C4I systems in the environment, requiring costly corrective action programs and probably reducing operational effectiveness.

- Spectrum planners, who develop frequency plans for DoD missions, are responsible for assigning frequencies to preclude EMI among the multitude of emitters and receivers that will operate in the battle space or in training exercises. Non-certified emitters and receivers constitute unknown quantities that present a hazard to spectrum planning and overall mission success, regardless of their operational frequencies.

6.3 Regulatory Organizations

Below are the major organizations who work individually and collectively to maintain and implement spectrum policy. Their functions and responsibilities cover all aspects of SM, from the broad regulatory aspects of spectrum use rules, to the specific procedural aspects of certifying equipment and obtaining assigned operational frequencies. Figure 3 depicts the overall SM structure.

6.3.1 International

6.3.1.1 International Telecommunication Union (ITU)

The first regulations governing wireless telegraphy were adopted in 1906 by the 20-member nation International Telegraph Convention after a widely recognized need to coordinate and control use of the spectrum. This organization later became the ITU, currently with approximately 200-member nations. The regulations, now known as the *Radio Regulations*, allocate the frequencies between 3 kHz and 300 GHz into bands for use by radio services worldwide. These regulations have been amended and revised over the years at World Radio Conferences (WRCs). The ITU comprises the following groups and activities:

- The Plenipotentiary Conference is the supreme authority of the union and meets every four years to adopt the strategic plan and fundamental policies of the organization.

- The Council is composed of 46 members of the union and acts on behalf of the plenipotentiary conference to consider broad telecommunication policy issues.

- The World Conferences on International Telecommunications meet according to needs, to establish the general principles related to the operation of International telecommunication services.

- The Radio Communication Sector ensures rational, equitable, efficient and economical use of the spectrum by all radio communication services.

- The Standardization Sector studies the technical, operating, and tariff questions and issues recommendations for standardizing telecommunications on a worldwide basis.

- The Development Sector facilitates and enhances telecommunications development by offering, organizing and coordinating technical cooperation and assistance activities.

- The General Secretariat handles all administrative and financial aspects of the ITU.

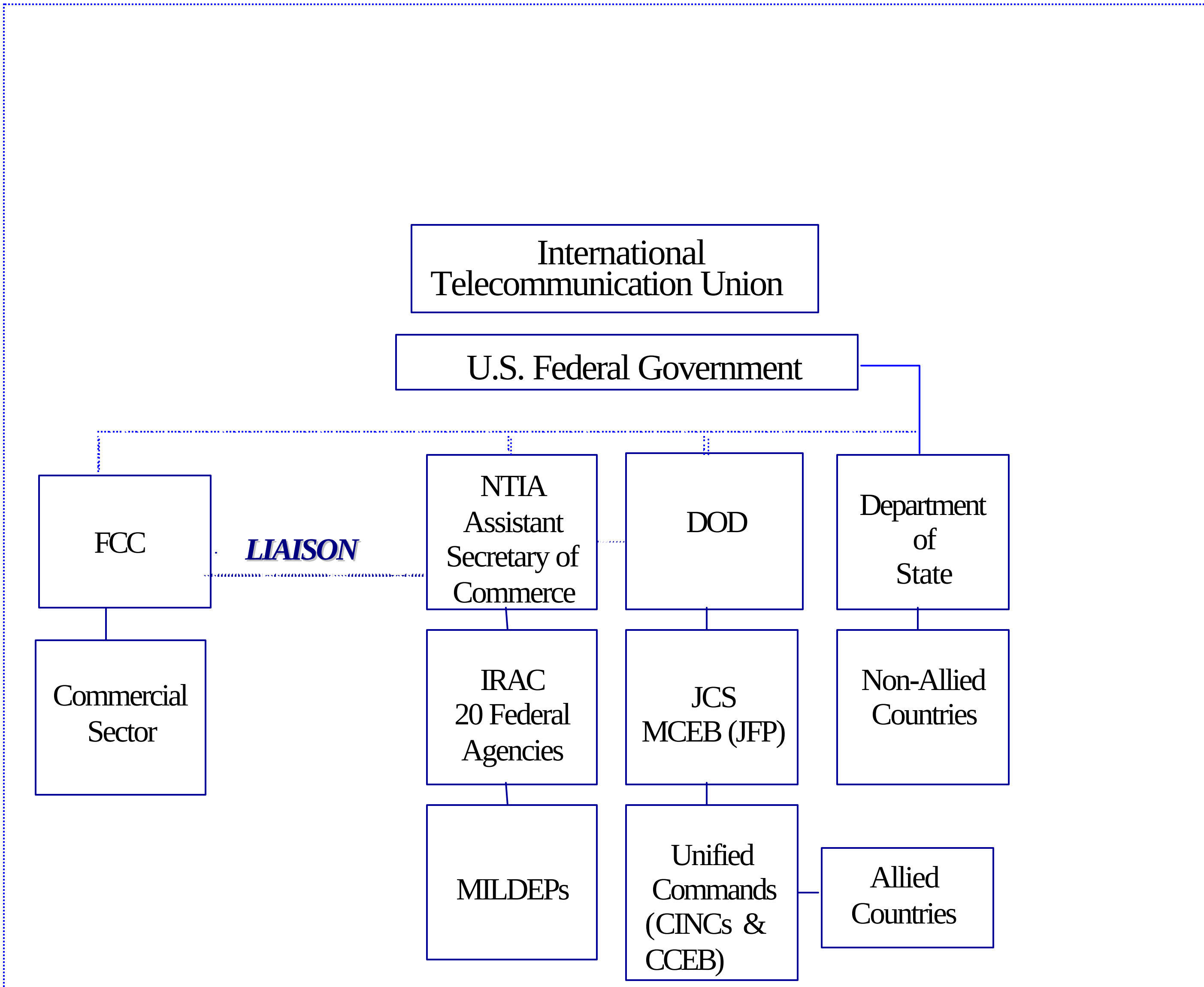

FIGURE 3. Spectrum Management Organizations.

6.3.2 National

6.3.2.1 Federal Communications Commission (FCC)

Congress has authority over civil portions of the spectrum. The Communications Act of 1934 established the FCC as an independent Government agency to control and manage civilian use of the spectrum. The FCC is directly responsible to Congress and charged with regulating civilian use of the spectrum by radio, television, wire, satellite, and cable. Their jurisdiction covers the 50 states, the District of Columbia, and U.S. and its possessions. Five Commissioners appointed by the President and confirmed by the Senate direct the Commission for 5-year terms. There are seven operating Bureaus: Cable Services, Common Carrier, Consumer Information, Enforcement, International, Mass Media, and Wireless Telecommunications. These Bureaus are responsible for developing and implementing regulatory programs, processing applications for licenses or other filings, analyzing complaints, conducting investigations, and taking part in FCC hearings.

6.3.2.2 National Telecommunication & Information Administration (NTIA)

The NTIA was established in 1978 under the Secretary of Commerce as the President's principal advisor on telecommunications policy. The Assistant Secretary acts as Administrator. Spectrum management within the organization is under the direction of its Associate Administrator, the Office of Spectrum Management. Among NTIA SM responsibilities are the following functions:

- Serve as the President's principal advisor on telecommunications policies pertaining to regulation of the telecommunications Industry,

- Advise the Director, Office of Management and Budget (OMB) on the development of policies for procurement and management of Federal telecommunications systems,

- Conduct research and analysis of electromagnetic propagation, radio system characteristics and operating techniques affecting spectrum use,

- Establish policies concerning frequency allocations and spectrum assignments for telecommunication systems owned and operated by the Government and provide guidance to various Agencies to ensure their compliance with policy,

- Develop, in cooperation with the FCC, a comprehensive long-range plan for improved management of all electromagnetic spectrum resources, including jointly determining the National Table of Frequency Allocations (TOA), and

- Continues operation of the *Interdepartment Radio Advisory Committee (IRAC)* to serve in an advisory capacity to the Assistant Secretary.

6.3.2.3 Interdepartment Radio Advisory Committee (IRAC)

The IRAC, now under jurisdiction of the NTIA, was originally formed in 1922 to manage the

Government's portion of the spectrum when Federal Departments and Agencies banded together under the Secretary of Commerce to coordinate their use. The Assistant Secretary of Commerce, under Executive Order 12046 of 1978 and the NTIA Organization Act, continued this relationship. The basic functions of the IRAC are to support the Assistant Secretary in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs, procedures, and technical criteria pertaining to the allocation, management, and use of the spectrum. The permanent substructure of the IRAC consists of the following:

- Frequency Assignment Subcommittee that carries out those functions related to the assignment and coordination of radio frequencies and the development and execution of related procedures;

- Spectrum Planning Subcommittee (SPS) that plans for use of the spectrum in the National interest, to include the apportionment of spectrum space for the support of established or anticipated radio services, as well as the apportionment of spectrum between or among Government and non-Government activities;

- Technical Subcommittee that carries out those functions related to technical aspects of use of the electromagnetic spectrum, and such other matters as the IRAC may direct. This committee evaluates and makes recommendations in the form of technical reports, regarding EMC capabilities and the needs of the Government in support of SM. They also develop recommended new standards and update existing standards pertaining to spectrum use;

- Radio Conference Subcommittee that carries out those functions that relate to preparing for ITU radio conferences, including the development of recommended U.S. proposals and positions;

- International Notification Group that prepares responses to the ITU concerning questionnaires and other correspondence related to U.S. frequency assignments; and,

- Secretariat that consists of the Executive Secretary, who is the principal officer, the Assistant Executive Secretary, and the Secretaries of the Subcommittees. They, together with the requisite technical and clerical personnel, carry out the work of the IRAC.

The IRAC has an active membership comprised of 20 Government Departments and Agencies, including each military Department, effectively representing all Federal users. A representative appointed by the FCC acts as liaison between the IRAC Subcommittees and the Commission, thereby creating a forum for addressing civil and Federal spectrum use interests.

6.3.3 Department of Defense

6.3.3.1 Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD(C3I))

ASD (C3I) is the DoD Spectrum Manager and, as such, is responsible for providing capabilities that enable the generation, use, and sharing of information among DoD forces necessary for mission success. Access to the spectrum is a major component of these required capabilities. To this end, ASD (C3I) ensures that DoD spectrum policy is represented interdepartmentally and internationally.

6.3.3.2 Joint Chiefs of Staff (JCS)

The rapid growth in sophisticated weapons systems, as well as intelligence, operations, and information systems, will increase demand for spectrum that, if not carefully coordinated and managed, will have an adverse effect upon Joint operations. The Joint Chiefs provide policy oversight on development of a Joint standard for exchange of spectrum-use data. They also identify, assess, and recommend measures to ensure that electromagnetic spectrum use is mutually supporting and effective in Joint and Combined operations. At the heart is Joint Vision 2020, which promotes achieving the ultimate goal of our military forces through Full Spectrum Dominance across the full range of operations. The Directorate for Command, Control, Communications, and Computer Systems (J-6) ensures adequate support to the Commanders in Chief (CINCs), the National Command Authority, and all warfighters for DoD and Joint operations, provides a permanent Military Communications Electronics Board (MCEB) Secretariat, and serves as chairman of the MCEB.

6.3.3.2.1 Military Communications Electronics Board (MCEB)

Although each of the Departments is represented in the IRAC and its subcommittees, development of common procedures for inter Service coordination is the responsibility of the DoD MCEB. The MCEB reports to the Secretary of Defense through the JCS and consists of the Chairman, senior C-E officers of the Army, Navy, Air Force, Marine Corps, and Coast Guard, and directors or senior representatives of DISA and National Security Agency. The MCEB is also responsible for developing and promoting the DoD position in negotiations with representatives of other host nations on C-E matters for which it is responsible. The Joint Frequency Panel (JFP) is concerned with SM issues. They review, develop, and coordinate studies, reports, and DoD positions regarding RF engineering and SM for MCEB consideration, with duties divided among eight working groups. The J-12 Working Group reviews newly submitted DD Form 1494s for the JFP or submits them to the JFP for other actions.

6.3.3.3 Office of Spectrum Analysis and Management (OSAM)

OSAM, an office in DISA, determines DoD’s future spectrum requirements, supports the WRC, coordinates analytical support, and positions the DoD to ensure spectrum access into the 21st century.

6.3.3.4 Joint Spectrum Center (JSC)

The JSC provides technical guidance and assists the DoD in effective use of the electromagnetic spectrum in support of National security and military objectives. It provides a National repository for spectrum usage data and SM support to OSAM, the Joint Staff (J-6), ASD (C3I), the Military Departments, CINCs, Joint Task Force Commanders, and component Commands. In addition, as related to the SC process, the JSC:

- Reviews all DD Form 1494 frequency allocation applications for the Services,

- Maintains spectrum use databases for planning and analysis, and

- Provides interference prediction and analysis modeling and simulation support.

6.3.3.5 US Army Communications-Electronics Services Office (USACESO)

The USACESO performs specialized spectrum management activities on behalf of the Army Spectrum Manager. It is the focal point for acquisition personnel, Major Army Commands, Major Subordinate and System Commands, and Materiel Support Commands who develop, purchase, or lease C-E equipment for use by the U.S. Army. It exercises technical control over the following Area Frequency Coordinators (AFC): Army Frequency Management Office – Continental United States, DoD AFC Arizona, and DoD AFC White Sands Missile Range (WSMR). In USACESO, the C-E Services J-12 Processing Center is responsible for the following SC functions::

- Prepares, reviews, and distributes completed applications to the MCEB, the SPS, and the CINCs, as appropriate,

- Coordinates applications with interested Army and other activities, and

- Forwards applications to the MCEB J-12 Working Group for approval.

6.3.3.6 Air Force Frequency Management Agency (AFFMA)

AFFMA secures and protects access to the spectrum for all Air Force requirements, Nationally and Internationally. With regard to spectrum certification it:

- Reviews DD Form 1494s for Air Force procurements,

- Assigns J/F-12 numbers and forwards Air Force DD Form 1494s to the MCEB Secretariat for distribution to all J/F-12 holders,

- Coordinates applications with interested Air Force directorates and other designated activities for review and comment, and

- Coordinates responses and drafts memos forwarding applications to the MCEB J-12 Working Group for approval.

6.3.3.7 Navy Electromagnetic Spectrum Center (NAVEMSCEN)

The Chief of Naval Operations CNO N6 has frequency approval authority for all Navy and Marine Corps systems. NAVEMSCEN is CNO's agent for managing the Navy's electromagnetic spectrum resources. NAVEMSCEN personnel represent the Navy on the MCEB J-12 Working Group and IRAC SPS. With regard to spectrum certification, NAVEMSCEN:

- Coordinates the Navy's spectrum resource usage,

- Reviews, coordinates, and processes SC applications, and

- Provides guidance, training, and procedures for SM.

6.3.3.8 Combined Communications Electronics Board (CCEB)

The CCEB is a five-nation military C-E organization committed to maximizing the effectiveness of combined operations, with regard to communication and information systems. Their mission is to ensure interoperability among member nations through the formulation of combined C-E policy and coordination of C-E issues. Originally formed by the U.S. and the United Kingdom in 1942 as the Combined Communications Board, the current CCEB was renamed in 1972 and also includes Canada (1951), Australia (1969), and New Zealand (1972). Within the organization, the Frequency Planners Meeting is one of the principal activities. This forum is directed towards ensuring adequate spectrum support for forces of the CCEB nations. While the CCEB does not control national procurement initiatives, or mandate the use of particular standards, it is expected that future equipment acquisition will be strongly influenced by the standards, policies, and procedures that the organization develops.

6.4 The Spectrum Certification Process

6.4.1 General

The purpose of the SC process is to ensure that DoD equipment, subsystems, and systems are designed and verified to conform to requirements of applicable International and National tables of allocated frequency bands and other spectrum policies. The methodology involves review of the technical and performance characteristics of an item during the procurement to determine compliance with requirements and provide guidance to the developer. Within the MCEB, the J-12 Working Group of the JFP is responsible for the review of all DoD frequency allocation applications. A J/F-12 number is assigned upon approval of the allocation application. The process:

- Provides authorization to develop or procure items that utilize a defined frequency band(s) or frequencies for the accommodation of a specific electronic function,

- Ensures compliance with the policies and tables which provide order in the use of the spectrum, and

- Ensures spectrum availability to support the item in its intended operational environment.

As required by DoDI 5000.2, spectrum supportability must be addressed at Milestone reviews. DD Form 1494s must be submitted in a timely and accurate manner. Processing time is dependent upon the quality of the data and is often delayed due to incomplete or erroneous information. Nominal time to complete the process is 3 - 9 months. A critical factor, however, can be the coordination period associated with HNA. Some countries may take years to complete coordination, whereas others may be as quick as 60 to 90 days for non-controversial systems. The process should be initiated once:

- Sufficient information becomes available on the intended use and feasible frequency limits of a proposed item to warrant consideration of a specific allocation,

- A system or equipment is being considered for development, or

- Procurement of CI or leasing of a commercial service for military use is being considered.

6.4.2 Overview of the Process

An overview of the DoD SC process is shown in Figure 4. Contractors may supply the technical equipment characteristics data required by DD Form 1494 to the Program Office, who, in turn, provides a completed DD Form 1494 along with any applicable releasability instructions to the sponsoring Military Departmental FMO (AFFMA, NAVEMSCEN, or USACESO) for review and comment. Once complete, the sponsoring Department then submits the application to the J-12 Working Group for review and comment. At the same time, copies may be sent to the NTIA SPS for U.S. National approval. Releasable DD Form 1494s are sent to the CINCs for coordination of HNA. All comments flow back to the sponsoring Department who drafts the MCEB guidance for review by the J-12 group. Once allocation approval is obtained from the MCEB, the DISA/JSC places pertinent data about the item and its allocation into the Spectrum Certification System (SCS) database. The SCS is updated within one or two days of receipt of the information from the sponsoring department. Updates of the SCS are distributed worldwide on a semi-annual basis to DoD organizations and Military Departments.

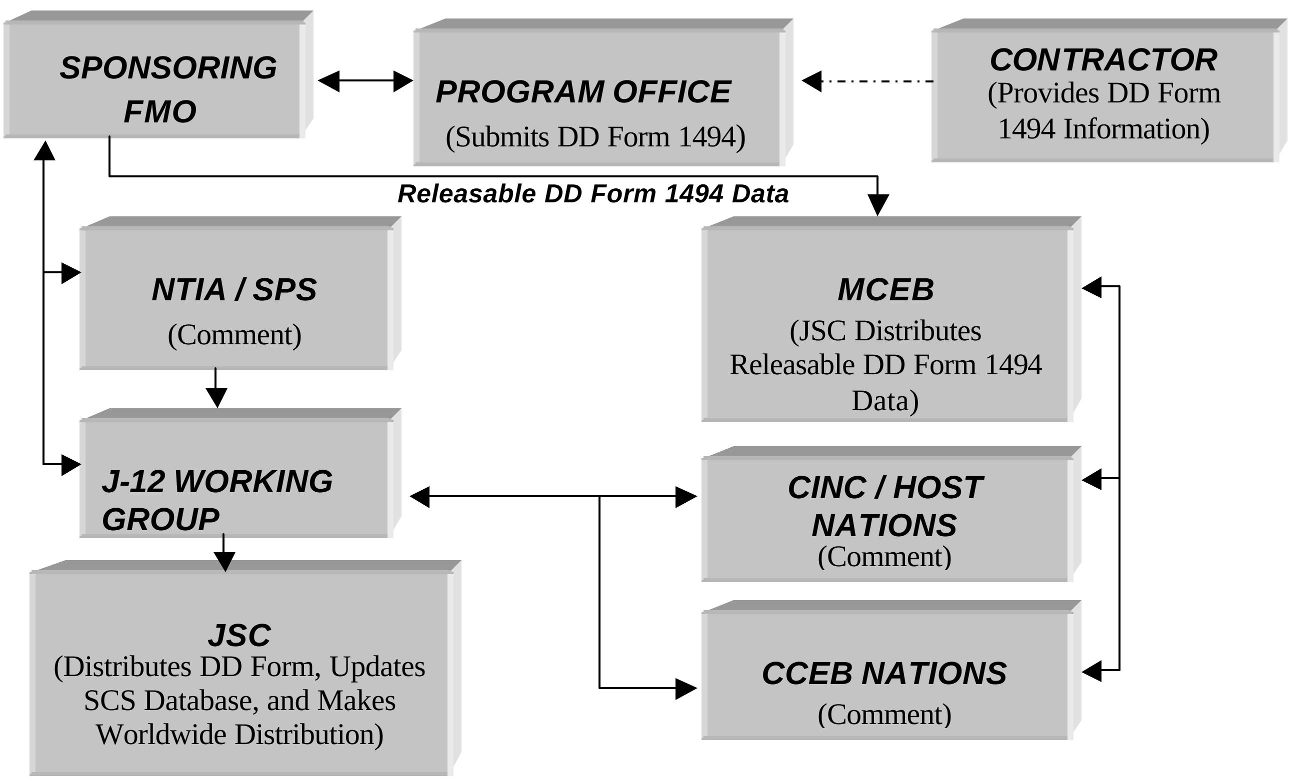

FIGURE 4. Overview of the Spectrum Certification Process.

6.4.3 Submission of DD Form 1494

The DD Form 1494 is submitted at times commensurate with an acquisition item's procurement cycle. These times are defined in DoDI 5000.2, DoDD 4650.1, and the DD Form 1494 itself. The importance of timeliness in these submissions cannot be overstated. The forms must be submitted in sufficient time to allow for processing. With each allocation submission, data requirements with respect to equipment technical characteristics and performance progressively increase. With the final submission, all data blocks requiring technical data should be completed with measured data. Calculated data generally is not acceptable.

6.4.3.1 Selection of Frequency Band

All major DoD acquisition programs are based on identified, documented, and validated mission needs. Definition of the mission provides a means for deriving the telecommunication needs of the system and, therefore, serves as a meaningful basis for preliminary preparation of spectrum support requirements. The International and National TOAs define the usable spectrum for specific radio services in accordance with International treaties. This is a preliminary source for identifying potential frequency band requirements based on the intended radio service, that is, communications, navigation, radiolocation, and so forth. Next, the requirement should be assessed in conjunction with state-of-the-art technology to determine whether certain technical factors might lead to the selection of specific frequency bands that are ideally suited. A determination should be made as to whether some bands ideally suited from a technical standpoint might be impractical for other reasons and should be rejected. Overcrowding might be one such reason, as might operating restrictions imposed by DoD, Federal, and International rules and regulations that govern the selected bands. It is also very important to consider where the system will be installed during the testing and operational phases of its life cycle.

Before finalizing the band selection process, a review should be made of existing frequency assignments that are authorized for equipment operating in the area(s) intended for location of the system. In addition, a survey should be conducted of the number of systems in the DoD inventory that may be impacted by the new or modified system. Once completed, the survey will provide insight on potential impacts to other systems in the intended environment that could result in rejection, or long, costly delay of approval of the frequency allocation application. The survey will additionally provide insight as to whether the proposed system may be adversely impacted by other systems in the environment, which could lead to selection of another band option. Normally, the frequency band selected will be one of those allocated to the radio service in question, as specified in the NTIA TOA. Bands other than those identified in the TOA, however, may be proposed if operational, technical, and economic justifications are provided. Upon identification of the appropriate operational frequency band, the DD Form 1494 can be initiated.

6.4.3.2 Completing the Form

The DISA/JSC has developed the SCS - Data Maintenance and Retrieval (SCS DMR) software application to automate portions of the spectrum certification process by organizing and compiling the information required by DD Form 1494. The SCS DMR software application and user manual can be downloaded from the Internet by completing a registration form at www.jsc.mil. The SCS DMR application provides the following capabilities:

- Aids in simplifying the entry and maintenance of spectrum certification data in a structured database,

- Provides a database retrieval capability,

- Generates and prints the completed application, and

- Outputs records for transfer to other users.

The DD Form 1494 is a multi-page document used to coordinate applications for equipment frequency allocations, both Nationally and Internationally. The form, composed of the eight pages, described below may be assembled in different order depending on the forum to which it is being submitted for evaluation. The back of each page contains detailed instructions for completing each question block.

- DoD General Information Page - The first page of the application contains general information concerning the nomenclature, use, number of equipment types that make up the system, and the frequency requirements.

- Transmitter Equipment Characteristics Page - The second page documents transmitter equipment characteristics. All technical characteristics required here, such as the tuning range, output power, RF channeling capability, emission bandwidth, and so forth, are evaluated in accordance with DoD requirements to determine suitability of the system for operation in the intended EME.

- Receiver Equipment Characteristics Page - This page consists of information related to receiver characteristics. Again, the receiver must be suitable to survive the rigors of the militarized EME. The required data items are evaluated against performance requirements to determine the ability of the equipment to discern and process desired signals in the intended operational environment. With a multi-receiver system, a copy of the receiver page should be submitted for each different receiver.

- Antenna Equipment Characteristics Page - It is very common for separate receiver and transmitter antennas to be employed or for several different antennas to be associated with the same transmitter. No attempt should be made to describe several antennas on the same page. Use the “Remarks” block to describe any unusual characteristics of the antenna, particularly as they relate to the assessment of EMC, and to clarify any other antenna information provided.

- Line Diagram Page – This is one of two blank pages that the DD Form 1494 provides to allow for further description of the system. This page provides space for a line diagram to provide graphical illustration of the equipment.

- Continuation Page - The Remarks Continuation page is provided to continue any remarks needed in reference to any of the other six pages. Continuation pages are allowed.

- NTIA General Information Page - This page requires much of the same information required by the DoD General Information page, however, it provides a format acceptable to the IRAC SPS along with other specific required information. The DoD General Information page is removed prior to submission of the application to the SPS. The NTIA page is used to begin U.S. National coordination with other Government Agencies via the SPS review process. Any Agency that is a member of the SPS can impact approval of an application based on the information provided, or not provided. Use of the continuation and line diagram sheets is strongly recommended to ensure that application information is clear when submitted. Completeness is a critical factor is obtaining timely approval.

- Foreign Coordination General Information Page – This page is intended only for equipment that will be operated outside the U.S, and Possessions. Foreign disclosure authority is required for coordination to obtain spectrum support from countries where the equipment may operate. Consequently, the release of technical information contained in DD Form 1494 to these countries is necessary. Such information, however, may not be released without first obtaining foreign disclosure approval. Action must be initiated to obtain foreign disclosure authority in accordance with Military Department regulations and policies for the release of appropriate data to the proposed host nations. A foreign coordination version of DD Form 1494 is treated as a completely separate document from a U.S. coordination version. This page should not be completed unless foreign coordination of the system is intended.

6.4.4 Frequency Assignments

Designated authorities, such as AFCs or Unified and Specified Commanders grant frequency assignments. A frequency assignment will not normally be granted for equipment not having an approved DD Form 1494. Procedures for obtaining frequency assignments are delineated in the Service regulations. (See Appendix A).

6.4.5 Note-To-Holders

A "Note-to-Holders" is a mechanism provided by the SC process to permit minor changes to an existing frequency allocation in lieu of generating a new, separate allocation. The types of modifications permitted include:

- Adding the nomenclatures(s) of equipment which have essentially identical technical and operating characteristics as a currently allocated item,

- Adding comments that have been provided by the NTIA or host nations,

- Documenting minor modifications, or improvements to equipment that do not essentially alter the operating characteristics (transmission, reception, frequency response) of an item, or

- Announcing the cancellation or reinstatement of a frequency allocation.

7. E3/SC TEST STRATEGY

7.1 General

Information is required to make risk assessments, to validate M&S, to determine compliance with technical performance specifications, and to determine whether an item is operationally effective, suitable, and survivable for its intended use. A program must be structured to integrate all applicable verification activities, including T&E and M&S, that will be conducted during an item's life cycle. Objectives for each phase of a program are to be designed to allow assessment of performance appropriate to each phase and milestone. However, until an item is actually tested, there is no assurance that it possesses the desired characteristics. Verification efforts usually occur at a number of stages in a program, as described below:

- Stage 1 - Subsystem/equipment qualification testing (including EMI) usually performed in a factory, laboratory, or Open Area Test Site (OATS)

- Stage 2 - Subsystem/equipment installation inspection (visual) to determine if an item was installed properly (that is, grounding, bonding, cable separation, and so forth)

- Stage 3 - Functional tests to determine whether subsystems/equipment meet their performance specifications after installation

- Stage 4 – Intra-subsystem tests to show that equipment comprising a functional subsystem (that is, radar, fire control, machinery control, communications, and so forth) satisfactorily operate together. This will also show that the subsystem is free from self-generated, or internal, EMI.

- Stage 5 – Inter-subsystem/equipment (or intra-platform/system) testing and analysis to demonstrate whether the items on the platform/system are functioning so that the platform/system can perform its mission(s). This will also verify that all subsystems/equipment within the platform/system effectively operate without degrading each other's performance due to E3.

- Stage 6 - Total platform/system test and analysis to verify that all subsystems/equipment satisfactorily demonstrate their operational performance with all items operating in an EME representative of a battle space scenario. These operational tests or analyses assess intra-platform/system and inter platform/system interactions that can occur between radar, communications subsystems, weapons subsystems, ordnance, and so forth. Tests are not one-on-one interactions but, rather, a full operational test of all sensors and radiators operating in the EME whether from own platform/system or others in the vicinity.

Stages 1-4 are usually performed by the developing or integrating activity, whereas Stage 6 is usually performed by the OTA. Stage 5 may be performed by either or both the integrating activity or the OTA. Developmental and operational E3 testing and evaluations are performed during the stages described above and should be conducted on all Defense acquisition items. In addition, verification of specialized E3 requirements, such as for p-static, lightning, EMP, HERP, HERF, and HERO may be required on a case-by-case basis, as discussed in 7.2.4 of this document.

It is intended that limitations of operational capabilities caused by E3 be minimized and that the limitations and vulnerabilities that remain after deployment be documented. Plans must be formulated as early as possible to ensure that during T&E potentially adverse E3 and spectrum supportability problems are identified. Both developmental and operational testers must be involved early to ensure that the test program can support the acquisition strategy, the harmonization of objectives, thresholds, and MOEs/MOPs with appropriate quantitative criteria, and effective performance in the operational EME is demonstrated.

7.2 Developmental Test & Evaluation (DT&E)

7.2.1 General

Developmental testing will demonstrate that the engineering design and development process is complete, that E3 risks have been minimized, and that the item will be in compliance with its contractual E3 specifications, based on tailored military standards (such as MIL-STD-461 or 464) or commercial standards. Developmental testing will usually be planned and conducted by the developer in a factory, laboratory, or OATS. These tests include Production Acceptance Tests and Evaluation and first article E3 testing after an item has been approved for full-rate production. A final step in a successful developmental test program is certification that the item is ready for OT&E.

7.2.2 Subsystems/Equipment

Developmental EMI requirements for subsystems/equipment, that is, conducted and radiated, emission and susceptibility (immunity) requirements, are defined in MIL-STD-461. The standard is discussed in greater detail in paragraph 4.2.3.2.2 of this handbook. Verification of the EMI requirements is also demonstrated by tests that are based on MIL-STD-461. The standard's Appendix should be consulted for detailed guidance on tailoring and performing the required tests. Compliance with the equipment-level EMI requirements does not relieve the developing or integrating activity of the responsibility for providing overall platform/system compatibility. Furthermore, if CI/NDI is involved, sufficient testing must be done on the CI/NDI to ensure performance, operational effectiveness, and operational suitability for the military application. Testing of CI/NDI is discussed in paragraph 4.5.3 of this document.

7.2.3 Platforms/Systems

Developmental E3 requirements for airborne, sea, space, and ground platforms/systems, including associated ordnance, are defined in MIL-STD-464. The standard applies to complete platforms/ systems, both new and modified. Verification of the tailored E3 requirements is done by test, analysis, inspection, or some combination thereof, depending on the degree of confidence in the particular method, technical appropriateness, associated costs, and availability of assets. The standard's Appendix provides rationale and guidance for implementing the requirements and verification procedures contained therein. The standard is discussed in further detail in paragraph 4.2.3.2.3 of this handbook. Testing and/or analyses for intra-and inter-platform/system EMI, and EMV are universally applicable and are discussed below. Additional specialized E3 assessments, such as p-static, EMP, lightning, HERP, HERF, and HERO may also be required and are also discussed in 7.2.4 below.

7.2.3.1 Intra-Platform/System EMI Testing

The limits specified in MIL-STD-461 for subsystems/equipment are empirically derived levels to cover most configurations and environments. The limits have a proven record of success demonstrated by the relatively low incidence of problems at the platform/system level. However, while compliance with the EMI requirements assures a high degree of confidence of achieving platform/system compatibility, it does not guarantee it. Although tailoring may have been done, it may not have accounted for all of the peculiarities of the intended installation. Non-compliance with the EMI requirements often leads to operational problems. The greater the non-compliance, the higher the probability that a problem will develop. Since EMI requirements are a risk reduction initiative, adherence to them will afford a higher degree of confidence that the platform/system and its associated subsystems/equipment will operate compatibly upon integration. It is essential that within a platform/system, subsystems/equipment be capable of providing full performance along with other subsystems/equipment that are operating concurrently. EMI generated by a subsystem/equipment must not degrade the overall platform/system effectiveness. Intra-platform/system EMI is one of the basic elements of concern and is addressed in detail in MIL-STD-464.

7.2.3.2 Inter-Platform/System EMI Evaluations

Operational problems resulting from the adverse effects of electromagnetic energy from one platform/system to another are well documented. These problems underscore the importance of providing the warfighter with platforms/systems that are compatible with their intended operational EME. Joint service operations further increase the potential for safety and reliability problems, particularly if the platforms/systems are exposed to an operational EME different from those for which they were designed and tested. For example, Army platforms/systems, if designed to operate in a land EME, may be adversely affected by exposure to the Navy's shipboard environment as may be encountered in a Joint operation.

In addition, the threat presented by RF emitters around the world is becoming increasingly more serious. Increased multi-National military operations, proliferation of both friendly and hostile weapons, and the expanded use of the spectrum, worldwide, have resulted in an operational EME not previously encountered. It is therefore essential that the EME be defined and used to evaluate inter-platform/system performance. Tools such as the JSC's Joint E3 Evaluation Tool (JEET) described in Appendix C are available to support the required analyses. The EME in which military platforms/systems and their associated subsystems/equipment must operate is created by a multitude of sources. The contribution of each emitter may be described in terms of its individual characteristics, such as: power level, modulation, frequency, bandwidth, antenna gain (main beam and side lobe), antenna scanning, and so forth. These characteristics are important in determining the potential impact on performance. Many threats may be seen only infrequently. For example, a high-powered emitter may illuminate a platform/system or one of its subsystems/equipment for only a short time due to its search pattern. And too, it may operate at a frequency where effects are minimized. There are many different EME levels that can be encountered during an item's life cycle. MIL-STD-464 describes airborne, land-based, ship-based, air, and battle space EME levels and addresses the requirement for inter-platform/system EMI in detail. In addition, MIL-HDBK-235 contains friendly and hostile EME levels, as well as emitter characteristics.

7.2.3.3 EMV

Some inter-platform/system EMI testing may be performed under laboratory conditions where the item under test and the simulated EME are controlled. Detection of undesired responses during routine EMI testing might necessitate an EMV analysis to determine the impact of the laboratory observed susceptibility on operational performance. Operational testing in the actual EME rarely is effective in the investigation or verification of susceptibilities because there is much less control on variable conditions, fewer functions can generally be exercised, and expenses can be high. The results of EMV analyses and tests guide the possible need for modifications, additional analyses, or testing. The inter-platform/system environment is evaluated to determine which frequencies are of interest from the possible emitters to be encountered when deployed, optimum coupling frequencies, susceptibility of the subsystem/equipment, available simulators, and authorized test frequencies that can be radiated. The evaluations require descriptions of the EME, both friendly and hostile, which the item may encounter during its life cycle. Based on these considerations and other unique factors, a finite list of test emitters is derived. For each test emitter, the item is illuminated and evaluated for susceptibilities. These tests are usually carried out in specialized test chambers, that is mode stirred chambers, anechoic chambers, shielded or anechoic hangars, and so forth, depending on the size of the item being tested.

7.2.4 Verification of Special E3 Requirements

Verification efforts for the following special E3 requirements are described in MIL-STD-464 and are to be applied on a case-by-case basis, as noted in the ORD, TEMP, or contractual documents.

7.2.4.1 P-Static

The control of static charge accumulation is accomplished during the design and construction of the aircraft and its associated subsystems/equipment. An aircraft must be verified to not pose a hazard when exposed to p-static charging. Conductive coating resistance must be verified to fall within the required range to prevent excessive accumulation of charge. In addition, the metallic and composite structural members should be inspected to verify that they are adequately bonded and that electrically conductive hardware and finishes are used.

7.2.4.2 Lightning

Verification of lightning requirements is essential to demonstrate that the platform/system is protected from the lightning threat environment. During development, numerous tests and analyses are normally conducted to sort out the optimum design. These evaluations may be considered part of the verification process and must be properly documented. Flight testing of aircraft may occur prior to verification of lightning protection control. Under this circumstance, the flight test program should include restrictions to prohibit flights within a specified distance from thunder storms, usually 25 miles. Lightning flashes sometimes occur large distances from thunderstorm clouds and can occur up to an hour after the storm appears to have left the area. There are many documents that describe analysis and test approaches for lightning. These include MIL-STD-464, MIL-STD-1542, FAA Advisory Circular AC 20-136, and the Society of Automotive Engineers (SAE) AE-4L Committee Report AE4L-87-3.

7.2.4.3 EMP

For platforms/systems with an EMP requirement, verification is necessary to demonstrate that the control measures that have been implemented provide the required protection. Verification that the platform/system meets the EMP requirements in MIL-STD-464 is accomplished by demonstrating that the transient levels at the subsystem/equipment interfaces of mission critical subsystems/equipment do not exceed the MIL-STD-461, or other tailored hardness levels, and that the required design margins have been met. Mission critical items are those for which proper operation is critical or essential to the operation of the platform/system.

A combination of analysis and test is usually required to verify platform/system performance after being subjected to EMP. Analyses or models are necessary to determine the EMP field that can be coupled into the platform/system without causing damage. Existing coupling data on similar platforms/systems may be used to estimate the voltages and currents generated by the EMP at each interface of each mission critical subsystem/equipment. However, the complex geometry of a final platform/system design may be so different from that which was modeled that the electromagnetic behavior can be substantially altered. There are a number of ways to obtain platform/system excitation for purposes such as quality control or hardening evaluation. Testing for EMP may be done using an injection method where a pulse current is injected into the penetrating conductors at points outside the platform/system electromagnetic shielding barrier. Residual responses are measured and the operation of the mission critical subsystems/equipment is monitored for upset or damage. For example, in the case of an aircraft, single point excitation such as electrical connection of a signal source to a physical point on the external structure of the aircraft, can be done in a hangar and can reveal any obvious problems in the airframe shielding. As an alternative, a platform/system level test can be performed on a functioning platform/system using a high-level EMP simulator in a controlled test site. DoD has a number of such sites available for EMP testing, as described in Appendix C of this handbook.

The operational performance requirements for the platform/system must be met *after* exposure to the EMP field. At the instant of the EMP event, the electrical transients may cause some disruption of performance. However, immediately after the event, or within some specified time frame driven by the platform/system operational performance requirements, the item must function properly. EMP poses a threat only to electrical and electronic subsystems/equipment. There are no structural damage mechanisms; however, EMP-induced arcing of insulators on antenna systems can permanently damage the insulator, disabling the antenna.

7.2.4.4 EMR Hazards

It has been firmly established that sufficiently high electromagnetic fields can harm personnel, ignite fuels, and fire EIDs. Precautions must be exercised to ensure that unsafe conditions do not develop.

7.2.4.4.1 HERP

A HERP evaluation should be performed to determine safe distances for personnel from RF emitters. Safe distances can be determined from calculations based on RF emitter characteristics or by measurement. Once a distance has been determined, an inspection is required of the areas where personnel have access together with the antenna's pointing characteristics. If personnel have access to hazardous areas, appropriate measures must be taken such as warning signs and precautions in servicing publications, guidance manuals, operating manuals, and the like. The safety tolerance levels for EMR to personnel are defined in DoDI 6055.11.

Before a measurement survey is performed, calculations should be made to determine distances for starting measurements to avoid hazardous exposures to survey personnel and to prevent damage to instruments. Safe distance calculations are often based on the assumption that far-field conditions exist for the antenna. Consult your applicable Service publication in Appendix A of this handbook for techniques to calculate safe distances and for calculating the gains of certain types of antennas. Since hazard criteria are primarily based on average power density and field strength levels, caution needs to be exercised with the probes used for measurements because they have peak power limits above which burnout of probe sensing elements may occur. When multiple emitters are present and the emitters are not phase coherent, as is usually the case, the resultant power density is additive. This effect needs to be considered for both calculation and measurement approaches. In addition to the main beam hazard, localized hot spots may be produced by reflections of the transmitted energy from any metal structure.

7.2.4.4.2 HERF

The existence and extent of a fuel hazard is determined by comparing the actual power density to an established safety standard. The volatility and flash points of particular fuels will influence whether there is a hazard under varying EME conditions. The amount of current and, thus, the strength of a spark across a gap between two conductors depend on both the field intensity of the energy and how well the conductors act as a receiving antenna. Verification by inspection and analysis is usually done, with testing limited to special circumstances. T.O. 31Z-10-4 and OP 3565 provide procedures for determining safe operating distances. An important issue is that fuel hazard criteria are based on peak power, while personnel hazard criteria are based, primarily, on average power. Any area on a platform/system where fuel vapors may be present needs to be evaluated. Restrictions on the use of some transmitters may be necessary to ensure safety under certain operational conditions, such as refueling operations.

7.2.4.4.3 HERO

Adequate measures must be taken to protect ordnance from EM energy and the effectiveness of these measures must be verified to ensure safe and effective operational performance. HERO testing should include exposure of the ordnance to the test EME in all life-cycle configurations, including packaging, handling, storage, transportation, checkout, loading, unloading, and launch from the host platform/system to determine its susceptibility characteristics. The ordnance should be exposed to the test EME while being exercised with operating procedures associated with the aforementioned configurations. Verification methods must show that the ordnance device will not inadvertently operate, initiate, or be dudded. Methods used to determine HERO susceptibility characteristics require instrumenting the device using any number of possible techniques such as thermocouple and fiber optic temperature sensors, RF voltage or current detectors, temperature sensitive waxes, or substitution of more sensitive elements. Such instrumentation must not alter the overall sensitivity or response characteristics of the ordnance.

The test EME should simulate the operational EME to the maximum extent possible. This requires appropriate representation of the EME with respect to frequency, field strength or power density, field polarization, and illumination angle. For radar EME, representative pulse widths, pulse repetition frequencies, and beam dwell periods should be chosen to maximize response by the ordnance. In the high frequency range, transmitting antennas should be the same type used to produce the fields in operation. Determining resonance frequencies is a fundamental aspect of HERO testing. Where possible, swept frequency testing is the preferred means of determining resonance frequencies. Mode stirred (reverberation) chambers can be used effectively for creating a contained, swept frequency EME. Follow-on testing at a discrete, high level EME is recommended to determine actual susceptibility thresholds. After the susceptibility characteristics of the ordnance are ascertained, the platform/system operational EME must be determined to ensure that potentially hazardous EME levels are not present in areas where ordnance may be stored, handled, or used. Appendix A of MIL-STD-464 should be consulted for detailed rationale, guidance, and procedures to conduct HERO evaluations, as well as the JSC Ordnance E3 Risk Assessment Database (JOERAD).

7.3 Operational Test and Evaluation (OT&E)

7.3.1 General

Historically, failure to adequately verify platform/system or subsystem/equipment performance in an operational EME has resulted in costly delays, mission aborts, and reduced operational effectiveness. Therefore, in addition to the DT&E assessments described in paragraph 7.2, operational evaluations for E3/SC should be performed to determine if the item is operationally effective and suitable for the intended use. The user community or Services T&E Commands performs these evaluations. OT&E will demonstrate operational performance in the presence of other operating items and compliance with KPPs and COIs described in the TEMP. It will also identify any resulting limitations and vulnerabilities. These evaluations, which may include both tests and analyses, may also be used to formulate operational procedures and tactics for the item. OT&E should be accomplished in as realistic an operational EME as possible. It is important that resources and assets required for verification of E3 requirements be identified early in the program to ensure their availability when needed. The following guidance applies to operational E3 testing:

- Items used for verification should be production configuration, preferably the first article.

- The item should be up-to-date with respect to all approved engineering change proposals and modifications (both hardware and software).

- EMI qualification testing to either MIL-STD-461 or MIL-STD-464, as applicable, should be performed before operational testing to provide a performance baseline and to identify any areas that may require special attention during the operational testing.

- All items should be placed in modes of operation and, where applicable, in platform unique azimuths and elevations, that will maximize potential indications of interference or susceptibility, consistent with overall operational performance requirements.

- Any external electrical power used to operate the item should conform to the power quality standards of the platform/system.

- Any anomalies found should be evaluated to determine whether they are truly an E3 issue or some other type of malfunction or response.

- Any modifications resulting from verification efforts should be validated for effectiveness after they have been engineered.

- Margins need to be demonstrated wherever they are applicable.

7.3.2 Intra-Platform/System EMI Testing

As noted earlier, developmental testing of EMI requirements is a risk reduction initiative. Adherence affords a higher degree of confidence that the platform/system and its associated subsystems/equipment will function compatibly in the operational EME. Subsystems/equipment should be designed and integrated to coexist and to provide the operational performance required by the user. However, varying degrees of functionality may be necessary depending upon the operational requirements of individual items during particular missions. Certain subsystems/equipment may not need to be exercised at the time of operation of other subsystems/equipment. The following issues should be addressed during operational intra-platform/system EMI testing:

- Potential EMI source vs. victim pairs should be identified and systematically evaluated by exercising the subsystem/equipment onboard the platform/system through the various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.

- A frequency selection plan should be developed for antenna-connected transmitters and receivers. This plan should include:

  - Predictable interactions between transmitters and receivers such as those at transmitter and receiver fundamental frequencies, harmonics, intermodulation products, other spurious responses, and cross modulation,

  - Evaluation of transmitters and receivers across their entire operating frequency ranges, including emergency frequencies, and

  - Evaluation of EMI issues with subsystems/equipment, including ordnance.

- Margins should be demonstrated for subsystems/equipment, including ordnance.

- Operational evaluations of undesirable responses found in the laboratory environment should be performed.

- Testing should be conducted in an area where the ambient, or background, EME does not affect the validity of the test results. A dense environment can hamper efforts to evaluate the performance of antenna-connected receivers with respect to emissions of other subsystems/equipment installed in the platform/system.

- Testing should include all relevant external hardware such as weapons, stores, provisioned equipment (that is, those items installed in the platform/system by the user) and support equipment.

- Verify that any external electrical power conforms to applicable power quality standards.

- All subsystems/equipment should be capable of simultaneous operation using power supplied by the platform power. Power line distortion, harmonics, or transients should not degrade the operation of the subsystems/equipment using that power.

A common issue in intra-platform/system testing is the use of instrumentation during the test. The most common approach is to monitor subsystem/equipment performance through visual and aural displays and outputs. To do this, it may be necessary to modify cabling and electronics; however, these modifications may change subsystem/equipment responses and introduce unexpected problems. Care should be exercised when using such external instrumentation. The need to evaluate antenna-connected receivers across their operating frequency ranges is important for proper assessment. While it might be tempting to check a few channels of a receiver and conclude that there was no EMI, this practice should not be used. The use of modern circuitry with microprocessor clocks and power supply choppers necessitates that all antenna-connected outputs be monitored during intra-platform/system testing.

7.3.2.1 Additional Intra-Ship Concerns

The large number of high frequency transmitters, their high output power, and the construction techniques and materials used on modern ships make the presence of intermodulation interference (IMI) a reality. On surface ships, the high frequency transmissions induce a current flow in the hull. The various currents from the different transmitters mix in non-linearities within the hull to produce signals at sums and differences of the fundamental and harmonic frequencies of the incident signals. Tests and analyses to control the 19^{th} order and higher IMI are required to effectively manage the spectrum. Specific controls should be imposed to limit internal EM fields on ships to ensure that the variety of equipment used onboard, particularly CI/NDI, will be able to function with little, or no, performance degradation. Testing needs to be performed with ship subsystems/equipment operating under normal conditions to detect the electric fields below deck and to verify compliance with the applicable internal EME requirements.

7.3.3 Inter-Platform/System E3 Evaluations

As noted earlier, platform/system DT&E requirements are based on MIL-STD-464. In addition, a thorough operational analysis, including M&S, may be required to verify performance in all EME levels that may be encountered. The following list provides guidance on issues that should be addressed during operational inter-platform/system E3 evaluations, both testing and analyses:

- Potential EMI source vs. victim pairs from friendly, Joint and Combined forces should be identified and systematically evaluated by exercising the subsystems/equipment on each platform/system through their various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.

- A frequency selection or EMCON plan should be developed for antenna-connected transmitters and receivers on platforms/systems in the intended operational EME. This plan should include:

    - Predicable interactions between transmitters and receivers at fundamental frequencies and harmonics,

    - Evaluation of transmitters and receivers across their entire operating frequency range, including emergency frequencies, and

    - Evaluation of ordnance susceptibility and associated control measures (frequency and power management and spatial separation).

- Margins should be demonstrated for explosive subsystems and other relevant subsystems/ equipment.

- Operational evaluation of responses identified by M&S should be performed.

- Testing should be conducted in an area and at a time when the ambient, or background, EME does not affect the validity of the test results. An environment with dense utilization of the frequency spectrum can hamper efforts to evaluate performance.

- Testing should include all relevant external hardware such as weapons, stores, provisioned equipment (that is, items installed in the platform/system by the user), and support equipment.

7.3.3.1 Additional Ordnance Concerns

Inter-platform/system E3 testing involving ordnance should include preflight, captive-carry, and free-flight configurations of the ordnance. Pre-flight testing should be conducted to ensure that the platform/system successfully performs those pre-flight operations required during service use. Operations, such as mission or target data uploading and downloading, should be performed while exposing the ordnance to the test EME. Captive-carry testing is conducted to determine survivability following exposure to the main beam, operational EME. Since this test simulates the ordnance passing through the radar's main beam during takeoff from and landing on the host platform/system, the ordnance should be operated as it normally would be for those flight conditions. The duration of exposure to the EME from the main beam should be based on normal operational considerations. Verification of ordnance survivability may, in many cases, be made utilizing the ordnance built-in test function. However, if this is not possible, verification utilizing an appropriate test set is suggested. Free-flight testing of ordnance may be simulated utilizing an inert, instrumented, ordnance device suspended in a quiet, EM-free environment, such as an anechoic chamber. Use of the anechoic chamber is recommended to determine the RF points and aspect angles associated with specific susceptibilities determined as described in 7.2.4.4.3 of this document. The free-flight test program consists of evaluating weapon performance during the launch, cruise, and terminal phases of flight, while exposed to friendly and hostile EME

7.3.3.2 Additional Aircraft Concerns

A platform/system such as an aircraft often undergoes extensive development and integration tests prior to inter-platform/system and formal acceptance testing. The EME that may be encountered must be reviewed and the status of the aircraft with regard to the environment must be evaluated prior to flight. EMI testing of the subsystems/equipment can be used as a baseline of hardness. However, limited, inter-platform/system testing involving specific emitters may be necessary. If such tests are not performed, restrictions on allowable operations, such as aircraft flight paths, may need to be imposed.

7.4 Summary E3/SC T&E Checklist

As noted earlier, the items procured must be in compliance with established E3/SC policies and with the DT&E and OT&E requirements and COIs discussed earlier in this handbook. The following checklist should be used when developing and evaluating the adequacy of a planned verification program. The list should be used with those provided earlier in the handbook.

- Have developmental tests been planned to demonstrate compliance with the applicable contractual requirements, based on tailored MIL-STD-461 or 464 requirements?

- Have OT&E efforts been planned to identify and verify performance in the operational EME, or identify limitations in performance due to E3? (Note that all items are to be operated simultaneously and tested in all modes, both on the platform and against those same systems on other, or similar platforms.)

- Will sufficient data be taken to identify and resolve E3 risks?

- Have tests been planned to verify effectiveness of proposed spectrum control and usage?

- Have evaluations been planned to determine EMP hardness when required by the ORD?

- Have tests of HERO characteristics in Joint EME been planned for ordnance?

- Is sufficient data available to assess intra-and inter-system/platform EMI?

- Will tests provide adequate data for EMV analyses? Are items being tested in an EME where susceptibility has been identified during a laboratory test?

- Are properly trained test personnel available to operate the test equipment?

- Will CI/NDI be tested or analyzed against the applicable requirements of MIL-STD-461?

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8. NOTES

8.1 Intended Use

This handbook provides guidance for establishing an effective E3/SC program.

8.2 Supersession

This document supersedes all previous issues of MIL-HDBK-237.

8.3 Changes From Previous Issues

Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

8.4 Subject Term (Key Word) Listing

E3
E3/SC WIPT
EMC
EME
EMI
EMP
EMV
HERF
HERO
HERP
RADHAZ
Spectrum Certification
Spectrum Management

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APPENDIX A

BIBLIOGRAPHY

CONTENTS

A.1 General

This Appendix supplements the documents listed in section 2 of this handbook. It identifies many pertinent DoD and U.S. commercial documents relative to E3/SC. Additional documents such as those issued by the International Special Committee on Radio Interference (CISPR), the International Electrotechnical Commission (IEC), and Industry associations are discussed in EPS-0178 or are themselves listed in the documents included below.

A.2 Directives, Instructions, Regulations, and Manuals

DoD DIRECTIVES

DoDD 3222.3	DoD Electromagnetic Compatibility (EMC) Program
DoDD 4630.5	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDD 4650.1	Management and Use of the Radio Frequency Spectrum
DoDD 5000.1	The Defense Acquisition System

DoD INSTRUCTIONS

DoDI 4630.8	Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDI 5000.2	Operation of the Defense Acquisition System
DoDI 6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers

DoD REGULATIONS

DoDR 5000.2-R	Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs

CJCSI INSTRUCTIONS

CJCSI 3170.01	Requirements Generation System
CJCSI 3220.01	EM Spectrum Use in Joint Military Operations
CJCSI 6212.01	Interoperability and Supportability of National Security Systems (NSS) and Information Technology Systems (ITS)

OTHER DoD DOCUMENTS

DFAR Supplement 252.235-7003	DoD Federal Acquisition Regulations Clause, Frequency Authorization Act
DoDISS	Department of Defense Index of Specifications and Standards

DoD 5010.12-L	DoD Acquisition Management Systems and Data Requirements Control List
DOT&E Memo	Policy on Operational Test and Evaluation of Electromagnetic Environmental Effects and Spectrum Management, 25 Oct 1999
NACSEM 5112	NONSTOP Evaluation Techniques
NSTISSAM TEMPEST/1-92	Compromising Emanations Laboratory Test Requirements, Electromagnetics
NSTISSAM TEMPEST/1-93	Compromising Emanations Field Test Evaluations
NSTISSAM TEMPEST/2-95	Red/Black Installation Guidelines
USD(A&T) Memorandum	Requirements for Compliance with Reform Legislation for Information Technology (IT) Acquisitions (Including National Security Systems), 1 May 1997

DEPARTMENT OF COMMERCE

NTIA Manual	Manual of Regulations and Procedures for Federal Radio Frequency Management

FEDERAL AVIATION ADMINISTRATION (FAA)

DOT/FAA/CT-89-2	Aircraft Lightning Handbook
FAA Advisory Circular AC 20/136	Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning

FEDERAL COMMUNICATIONS COMMISSION (FCC)

Code of Federal Regulations (CFR) 47 Part 15	RF Devices
CFR 47 Part 18	Industrial, Scientific and Medical Equipment

OFFICE OF MANAGEMENT AND BUDGET (OMB)

OMB Circular A-11	Preparation and Submission of Budget Estimates

A.3 Standards

MILITARY STANDARDS

MIL-STD-188-125	HEMP Protection for Ground Based C4I Facilities Performing Critical, Time Urgent Missions
MIL-STD-220	Method of Insertion Loss Measurement

MIL-STD-449	Test Method Standard, Radio Frequency Spectrum Characteristics, Measurement of
MIL-STD-331	Fuze and Fuze Components, Environmental and Performance Tests for
MIL-STD-461	Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (MIL-STD-461E consolidates MIL-STD-461 and 462)
MIL-STD-464	Interface Standard, Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-469	Interface Standard: Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-STD-704	Aircraft Electrical Power Characteristics
MIL-STD-1275	Characteristics of 28VDC Electrical Systems in Military Vehicles
MIL-STD-1310	Standard Practice Document: Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1377	Effectiveness of Cable, Connector, and Weapon Enclosure Shielding and Filters in Precluding Hazards of Electromagnetic Radiation to Ordnance, Measurement of
MIL-STD-1399	Interface Standard for Shipboard Systems
MIL-STD-1539 (AF)	Electric Power, DC, Space Vehicle Design Requirements
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1542	Electromagnetic Compatibility and Grounding Requirements for Space Systems
MIL-STD-1576	Guidance on the Use and Test of Ordnance in Space and Launch Vehicles
MIL-STD-1605	Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships)
DoD-STD-2106	Development of Shipboard Industrial Test Procedures
MIL-STD-2169	High Altitude Electromagnetic Pulse Environment

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/IEEE C63.2	Standard for Instrumentation - Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz - Specifications
ANSI/IEEE C63.4	Standard for Electromagnetic Compatibility – Radio - Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz - Methods of Measurement
ANSI/IEEE C63.12	Standard for Electromagnetic Compatibility Limits - Recommended Practice
ANSI/IEEE C63.14	Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD)

ANSIIEEE C95.1	Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (3 kHz - 300 GHz)
ANSI/IEEE C95.2/ ANS N2.1	Radio Frequency Radiation Warning Symbol
ANSI/IEEE C95.3	Techniques and Instrumentation for Measurement of Potentially Hazardous Electromagnetic Radiation at Microwave Frequencies
ANSI/IEEE C95.4	Safety Guide for the Prevention of RF Radiation Hazard in the Use of Electric Blasting Caps

RADIO TECHNICAL COMMITTEE FOR AERONAUTICS (RTCA)

RTCA DO-160D	Environmental Conditions and Test Procedures for Airborne Equipment

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AE4L-87-3	Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning
SAE-J551	Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices
SAE-J1113	Electromagnetic Susceptibility Measurement Procedures for Vehicle Components (Except Aircraft)
SAE ARP 1173	Test Procedures for Measuring the RF Shielding Characteristics of EMI Gaskets
SAE ARP 1972	Measurement Practices and Procedures Recommended for Electromagnetic Compatibility Testing

NORTH ATLANTIC TREATY ORGANIZATION (NATO) STANDARD AGREEMENTS (STANAGS)

STANAG 1008	Electrical Power Characteristics for Ships
STANAG 1234	Procedures for RADHAZ Control in Ports and Territorial Sea
STANAG 1307	Maximum NATO Naval Operational EME Produced by Radar and Radio
STANAG 3516	EMC Test Methods for Aerospace Electrical and Electronic Equipment
STANAG 3614	EMC of Installed Equipment in Aircraft
STANAG 3659	Bonding and In-flight Lightning
STANAG 3731	Bibliography on EMC
STANAG 3855	Lightning Qualification Test Techniques
STANAG 3968	NATO Glossary of EM Terminology

STANAG 4234	EM Radiation, 200 kHz – 40 GHz, Environment Affecting the Design of Material for Use By NATO Forces
STANAG 4236	Lightning
STANAG 4237	EEDs
STANAG 4327	Lightning Test Procedures
STANAG 4435	EMC Test Procedures and Requirements for Surface Ships (Metallic)
STANAG 4436	EMC Test Procedures and Requirements for Surface Ships (Non-metallic)
STANAG 4437	EMC Test Procedures and Requirements for Submarines

A.4 Data Item Descriptions (DIDs)

DI-R-2055	EMC Test Plan (MIL-STD-469)
DI-R-2056	EMC Control Plan (MIL-STD-469)
DI-R-2057	EMC Test Report (MIL-STD-469)
DI-R-2058	EMCON Test Plan (MIL-STD-469)
DI-R-2059	EMCON Test Report (MIL-STD-469)
DI-R-2060	EMCON Design & Development Plan (MIL-STD-469)
DI-R-2068	Spectrum Signature Test Plan (MIL-STD-449)
DI-R-2069	Spectrum Signature Test Report (MIL-STD-449)
UDI-R-22550	EMP Hardening Plan
UDI-R-22551	EMP Hardening Report
UDI-R-22574	Radiation Hazard Report
UDI-R-22577	Analysis of Interference Potential Report
UDI-R-23723	EMI Test Report - Survey (MIL-STD-1605)
UDI-T-30708	Antenna Pattern Report
DI-EMCS-80157	Suspected RF Radiation Overexposure Report
DI-EMCS-80199B	EMI Control Procedures (MIL-STD-461)
DI-EMCS-80200B	EMI Test Report (MIL-STD-461)
DI-EMCS-80201B	EMI Test Procedures (MIL-STD-461)
DI-EMCS-80849	Lighting Protection Plan (LPP) (MIL-STD-1795)
DI-EMCS-80850	Lighting Protection Verification Plan
DI-EMCS-80851	Lighting Protection Verification Report
DI-EMCS-81540	E3 Integration and Analysis Report (MIL-STD-464)
DI-EMCS-81541	E3 Verification Procedures (MIL-STD-464)
DI-EMCS-81542	E3 Verification Report (MIL-STD-464)
DI-NUOR-80156	Nuclear Survivability Program Plan
DI-NUOR-80926	Nuclear Survivability Assurance Plan
DI-NUOR-80928	Nuclear Survivability Test Plan
DI-NUOR-80929	Nuclear Survivability Test Report
DI-MISC-81113	Radar Spectrum Management Test Plan (MIL-STD-469)
DI-MISC-81114	Radar Spectrum Management Control Plan (MIL-STD-469)
DI-MISC-81174	Frequency Allocation Data

A.5 Guidance Documents, Handbooks, Specifications, and Studies

MIL-HDBK-235	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems
MIL-HDBK-241	Design Guide for EMI Reduction of Power Supplies
MIL-HDBK-253	Guidance for the Design and Test of Systems Protected Against the Effects of EM Energy
MIL-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-HDBK-274	Electrical Grounding for Aircraft Safety
MIL-HDBK-293	ECCM Considerations in Radar Systems Acquisitions
MIL-HDBK-294	ECCM Considerations in Naval Communications Systems
MIL-HDBK-335	Management and Design Guidance for EM Radiation Hardness for Air Launched Ordnance Systems
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipment and Facilities
MIL-HDBK-423	HEMP Protection for Fixed and Transportable Ground Based Facilities
MIL-HDBK-1857	Grounding, Bonding and Shielding Design Practices
MIL-I-17161	Absorber, Radio Frequency Radiation (Microwave Absorbing Material), General Specification for
SD-2	Buying Commercial and Non Developmental Items (CI/NDI)
SD-16	Communicating Requirements
EPS-0178	Results of Detailed Comparisons of Individual EMC Requirements and Test Procedures Delineated in Major National and International Commercial Standards with Military Standard MIL-STD-461E

A.6 Service Documents

DEPARTMENT OF THE ARMY

ADS-37A-PRF	Aeronautical Design Standard, E3 Performance and Verification Requirements (Aviation and Missile Command Report)
AR 5-12	Army Management of the Electromagnetic Spectrum
AR-70-1	Systems Acquisition Policy and Procedures
AR-70-75	Survivability of Army Materiel and Equipment
AR-71-9	Material Objectives and Requirements
AR-73-1	Army Test and Evaluation Policy
DA PAM 70-3	Army Acquisition Procedures
DA PAM 73-2	T&E Master Plan, Procedures and Guidelines

DA PAM 73-3	Critical Operational Issues and Criteria (COIC) Procedures and Guidelines
FM-11-490-30	Electromagnetic Radiation Hazards
TR-RD-TE-97-01	EM Effects Criteria and Guidelines for EMRH, EMRO, Lightning Effects, ESD, EMP and EMI Testing of US Army Missile Systems (Redstone Technical Test Center Report)

DEPARTMENT OF THE NAVY

SECNAVINST 2410.1	EMC Program Within the Department of the Navy
SECNAVINST 5000.2	Implementation and Mandatory Procedures for Major and Non-major Acquisition Programs
OPNAVINST 2400.20	Navy Management of the Radio Frequency Spectrum
OPNAVINST 2410.11	Procedures for the Processing of Radio Frequency Applications for the Development and Procurement of Electronic Equipment
OPNAVINST 2450.2	EMC Program within the Department of the Navy
OPNAVINST 3960.10	Test and Evaluation
OPNAVINST 5000.42	Research, Development, and Acquisition Procedures
OD 30393	Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance
OP-3565/NAVAIR 16-1-529/SPAWAR 0967-LP-624-6010	Volume I - Technical Manual, Electromagnetic Radiation Hazards (Hazards to Personnel, Fuel, and other Flammable Material) Volume II - Technical Manual, Electromagnetic Radiation Hazards (Hazards to Ordnance)
NAVSEAINST 8020.7B	Hazards of Electromagnetic Radiation to Ordnance (HERO) Safety Program
NAVSEAINST 8020.17	Navy Explosives Hazard Classification Program
S9407-AB-HDBK-010	Handbook of Shipboard Electromagnetic Shielding Practices

DEPARTMENT OF THE AIR FORCE

AFOSH Standard 48-9	Exposure to Radio Frequency Radiation Safety Program
AFI 32-7061	The Environmental Impact Analysis Process
AFI 99-102	Operational Test & Evaluation
AFI 99-106	Joint test and Evaluation
AFMAN 33-140	Radio Frequency Spectrum Management
AFPD 63-1	Acquisition System
AFPD 99-1	Test and Evaluation Process
AFSC DH 1-4	Air Force Systems Command Design Handbook, EMC
TO 31Z-10-4	Electromagnetic Radiation Management

MARINE CORPS SYSTEMS COMMAND (MARCORSYSCOM)

MCO 2400.2	Marine Corps Management of the Radio Frequency Spectrum
MCO 2410.2	Electromagnetic Environmental Effects Control Program
MCO 5104.2	Marine Corps Radio Frequency Electromagnetic Field Personnel Protection Program

A.7 Specific Regulations, Directives and Instructions Affecting Policy

Federal and DoD regulations exist, as well as DoD directives and instructions, which set the E3/SC policies with regard to the acquisition and fielding of military C-E equipment. The following paragraphs summarize the policies established by these documents.

A.7.1 Federal

A.7.1.1 Code of Federal Regulations

- TITLE 47, CHAPTER I, PART 2, Subpart B, Section 2.103 provides regulations pertaining to Government use of non-Government frequencies.

- CHAPTER III, PART 300, Sec. 300.1 indicates that Federal Agencies shall comply with the requirements set forth in the NTIA Manual, which is incorporated by reference with approval of the Director, Office of the Federal Register, in accordance with 5 U.S.C. 552(a) and 1 CFR part 51.

A.7.1.2 OMB Circular A-11

Section 34.1 states that the NTIA Department of Commerce must provide a certification by that the RF required is available before estimates are submitted for the development or procurement of major C-E systems, including all systems employing space satellite techniques.

A.7.1.3 NTIA Manual of Regulations & Procedures for Federal Radio Frequency Management

The entire NTIA manual is devoted to minimum Federal standards, regulations, and procedures for RF management. It is available on: www.ntia.doc.gov/osmhome/redbook/redbook.html.

A.7.2 DoD

A.7.2.1 DFAR Supplement 252.235-7003

This document requires specific clauses in solicitations and contracts for developing, producing, constructing, testing, or operating a device requiring a frequency authorization. The clauses require contractors to obtain authorization for RF needed in support of the contract and associated procedures.

A.7.2.2 DoDD 5000.1

This directive provides policies and principles for DoD acquisition programs. It requires that acquisition programs be managed to optimize total system performance, including consideration of SM and the operational EME.

A.7.2.3 DoDI 5000.2

This instruction establishes a general approach for managing acquisition programs. It notes that information superiority and interoperability are key attributes of systems. In this regard, the instruction states that all programs shall be managed and engineered using best processes and practices, shall be designed to be mutually compatible with other electric and electronic equipment and the operational EME, and shall be certified at milestone reviews for spectrum supportability.

A.7.2.4 DoDR 5000.2-R

This document requires the following, as related to E3 and spectrum support:

- All electric or electronic systems shall be designed to be mutually compatible with other electric or electronic systems/equipment and the operational EME. Ordnance and their associated systems shall be designed to preclude inadvertent ignition and perform effectively during or after exposure to the operational EME.

- Electromagnetic spectrum dependent systems and equipment, including CI/NDI, shall comply with OMB Circular A-11 to determine spectrum supportability prior to initiating cost estimates for development or procurement.

- All DoD components shall obtain spectrum utilization guidance from the MCEB in accordance with DoDD 4650.1.

- Systems and equipment shall comply with applicable National and International SM statutes, policies and regulations.

A.7.2.5 DoDD 3222.3

This document establishes the DoD EMC Program. It also provides policies to ensure that all electric and electronic systems are designed to be mutually compatible with other such equipment in the expected operational EME and that EMC control is planned for and incorporated in all DoD acquisitions. A proposed revision of DoDD 3222.3 is entirely devoted to the DoD Joint E3 program and is in the final coordination process. The revision, which is awaiting signature:

- Updates policy for the DoD Joint E3 Program to ensure the DoD's effective use of systems in EME in support of national security and military objectives, and

- Assigns specific and joint responsibilities to DoD Components for various aspects of E3.

A.7.2.6 DoDD 4630.5

This directive provides policies and responsibilities for interoperability and supportability, including spectrum supportability, of IT and NSS. The instruction requires interoperability and supportability requirements be determined during the requirements definition and validation process.

A.7.2.7 DoDI 4630.8

This instruction establishes policies and responsibilities for ensuring interoperability and supportability of IT and NSS. Requirements are to be documented, coordinated, verified, and approved to achieve interoperability and supportability. Systems that rely upon or use IT or NSS capabilities are to be tested and certified for spectrum supportability and E3 as part of their interoperability assessment.

A.7.2.8 DoDD 4650.1

This instruction provides policy, responsibilities, and procedures for the use of the electromagnetic spectrum in DoD including spectrum certification, host nation coordination, and frequency supportability.

A.7.2.9 CJCSI 3170.01

This instruction establishes policies and procedures for developing, reviewing, validating, and approving the MNS, ORDs and CRDs. It states that safety issues regarding HERO and E3, as well as spectrum supportability for systems and equipment shall be addressed during requirements generation.

A.7.2.10 CJCSI 6212.01

CJCSI 6212.01 establishes policies and procedures for the J-6 Interoperability Requirements Certification of the MNS, ORDs, and CRDs, and for the J-6 Supportability Certification of C4ISPs. The instruction contains assessment criteria for the review of the MNS, ORDs, CRDs, and C4ISPs. Furthermore, the instruction indicates that the J-6 Interoperability Certification includes conformance with Joint NSS and ITS policies, which includes the requirement to be mutually compatible with systems in the EME and not be degraded below operational performance requirements due to E3. It further requires all proposed NSS and ITS systems that include spectrum dependent hardware, including CI/NDI, document spectrum certification of the hardware.

A.7.2.11 DOT&E E3 Policy Memo

This memo dated 25 October 1999 provides policy for DOT&E, OTAs and PMs. The policy is intended to more clearly define the role of OT&E in identifying potentially adverse E3 and spectrum availability situations.

APPENDIX B

ACRONYMS AND ABBREVIATIONS

B.1 General

This appendix contains acronyms and abbreviations used throughout this handbook.

B.2 Acronyms and Abbreviations

ACAT	Acquisition Category
ACETEF	Air Combat Environment Test and Evaluation Facility
ACTD	Advanced Concept Technology Demonstration
AFB	Air Force Base
AFC	Area Frequency Coordinator
AFFMA	Air Force Frequency Management Agency
AFFTC	Air Force Flight Test Center
AFRL	Air Force Research Laboratories
ANSI	American National Standards Institute
ARDEC	Armaments Research, Development, and Engineering Center
ARL	Army Research Laboratory
ASD (C3I)	Assistant Secretary of Defense for Command, Control, Communications, and Intelligence
ASPECTS	Automated Spectrum Planning, Engineering, Coordination, and Tracking System
ATC	Aberdeen Test Center
ATD	Advanced Technology Demonstration
ATEC	Army Test and Evaluation Command
BEES	Battle Force EMI Evaluation System
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISP	C4I Support Plan
C4ISR	C4I, Surveillance, and Reconnaissance
CCEB	Combined Communications-Electronics Board
CDRL	Contract Data Requirements List
C-E	Communications-Electronics
CECOM	Communication and Electronics Command
CE Mark	Indication of Compliance With European Directives
CENELEC	European Committee for Electrotechnical Standardization
CFR	Code of Federal Regulations
CI	Commercial Item
CINC	Commander in Chief
CISPR	International Special Committee on Radio Interference
CJCSI	Chairman of Joint Chiefs of Staff Instruction
CNO	Chief of Naval Operations
COI	Critical Operational Issue
CRD	Capstone Requirements Document
CW	Continuous Wave
DID	Data Item Description
DISA	Defense Information Systems Agency
DoD	Department of Defense

DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDISS	Department of Defense Index of Specifications and Standards
DoDR	Department of Defense Regulation
DOT&E	Director, Operational Test and Evaluation
DT&E	Developmental Test and Evaluation
E3	Electromagnetic Environmental Effects
EDM	Engineering Development Model
EED	Electro-Explosive Device
EID	Electrically Initiated Device
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMCON	Emission Control
EME	Electromagnetic Environment
EMEGS	Electromagnetic Environment Generating System
EMENG	Electromagnetic Engineering System
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EMV	Electromagnetic Vulnerability
EP	Electronic Protection
EPG	Electronic Proving Ground
EPS	Engineering Practice Study
ESD	Electrostatic Discharge
EU	European Union
EW	Electronic Warfare
FAA	Federal Aviation Administration
FAAT	First Article Acceptance Test
FCC	Federal Communications Commission
FMO	Frequency Management Office
FOC	Final Operating Capability
FRP	Full-Rate Production
HEMP	High Altitude Electromagnetic Pulse
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HNA	Host Nation Approval
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IIPT	Integrating Integrated Product Team
IMI	Intermodulation Interference
IOC	Initial Operating Capability
IOT&E	Initial Operational Test and Evaluation
IPT	Integrated Product Team
IRAC	Interdepartment Radio Advisory Committee
ISO	International Organization for Standardization
IT	Information Technology

ITS	Information Technology System
ITU	International Telecommunications Union
JCS	Joint Chiefs of Staff
JEET	Joint E3 Evaluation Tool
JFP	Joint Frequency Panel
JOERAD	JSC Ordnance E3 Risk Assessment Database
JSC	Joint Spectrum Center
JTIDS	Joint Tactical Information Distribution System
KPP	Key Performance Parameter
LRIP	Low-Rate Initial Production
M&S	Modeling and Simulation
MAE	Maximum Allowable Environment
MAIS	Major Automated Information System
MARCORSYSCOM	Marine Corps Systems Command
MCEB	Military Communications Electronic Board
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MIDLANT AFC	Mid-Atlantic Area Frequency Coordinator
MNS	Mission Need Statement
MOE	Measures of Effectiveness
MOP	Measures of Performance
MS	Milestone
MSC	Mode Stirred Chamber
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAVEMSCEN	Navy Electromagnetic Spectrum Center
NAVSEA	Naval Sea Systems Command
NAWCAD	Naval Air Warfare Center, Aircraft Division
NDI	Non Developmental Items
NRL	Naval Research Laboratory
NSS	National Security Systems
NSWCDD	Naval Surface Warfare Center, Dahlgren Division
NTIA	National Telecommunications and Information Administration
NUWC	Naval Undersea Warfare Center
OATS	Open Area Test Site
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
OPLAN	Operational Plan
ORD	Operational Requirements Document
OSAM	Office of Spectrum Analysis and Management
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
OTA	Operational Test Agency
PM	Program Manager
PRIMES	Preflight Integration of Munitions and Electronic Systems
PSA	Principal Staff Assistant
P-Static	Precipitation Static

RADHAZ	Radiation Hazards
RF	Radio Frequency
RTCA	Radio Technical Commission for Aeronautics
RTTC	Redstone Technical Test Center
SAE	Society of Automotive Engineers
SC	Spectrum Certification
SCS DMR	Spectrum Certification System Data Maintenance and Retrieval
SD	Standardization Document
SLAD	Survivability/Lethality Analysis Directorate
SM	Spectrum Management
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
SPS	Spectrum Planning Subcommittee
SSC	SPAWAR Systems Center
STANAG	NATO Standardization Agreement
T&E	Test and Evaluation
TACOM	Tank Automotive Command
TC	Technical Committee
TEMP	Test and Evaluation Master Plan
TOA	Table of Allocations
U.S.	United States
USACESO	US Army Communications-Electronics Services Office
USMC	United States Marine Corps
V/m	Volts per meter
WIPT	Working Level Integrated Product Team
WRC	World Radio Conference
WSMR	White Sands Missile Range

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APPENDIX C

E3/SC

TEST FACILITIES AND CAPABILITIES

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C.1 Army Facilities and Capabilities

C.1.1 Army Research Laboratory (ARL)

ARL has extensive resources to test and evaluate a system's performance in an EME. These capabilities can also be used to support the system analysis and evaluation process. The following are some of the specific ARL capabilities:

C.1.1.1 Electromagnetic Analysis Facility

Located in the Survivability/Lethality Analysis Directorate (SLAD), at White Sands Missile Range (WSMR), NM, this is a major facility originally developed to perform special EMI investigations on Army and foreign systems. The facility has three shielded anechoic chambers containing both a radar cross section measurement system and an antenna pattern measurement range. The chambers can accommodate virtually all Army weapon systems. The facility provides a full spectrum facility capable of conducting diverse types of electromagnetic investigations from 100 MHz to 18 GHz with electric field strengths in excess of 200 Volts/meter (V/m). The antenna pattern measurement system is capable of evaluating antenna systems over a frequency range from 100 MHz to 40 GHz. The frequency range of the radar cross section measurement system is 2-17.9 GHz. The facility can be used for EMI investigations, radar cross section measurements, low and high power microwave illuminations, antenna pattern measurements, radiated emission measurements, in-band and out-of-band RF threat emulations, as well as specialized projects involving millimeter waves and narrow pulse effects.

C.1.1.2 Electromagnetic Coupling Facility

This electromagnetic coupling facility located at the SLAD, Aberdeen Proving Ground, MD, supports the survivability analysis of developmental systems. System coupling characteristics can be determined which can then be used by design engineers in hardening systems against the effects of an EMP or other EME levels. The facility measures coupling levels when exposed to an externally radiated, low power EME. The low level coupling response is then scaled to determine the system response to the actual high level EME. The facility can also use current injection techniques to simulate the high level coupling to further analyze the system performance.

C.1.1.3 Special EMI Computer-Controlled Advanced Radar Emulator

Located in the ARL/SLAD at WSMR, this threat emulator possesses the capability to generate complex threat radar waveforms. The emulator utilizes a resident threat database and a user-friendly, microcomputer-based system controller to generate a broad output bandwidth from 0.05-18 GHz. The system is capable of current or future radar waveform generation through the emulation of antenna patterns and radar scans. Waveforms and scans are programmed with parameters obtained from an intelligence-generated threat database.

C.1.2 Army Test and Evaluation Command (ATEC)/Development Test Command Test Centers

C.1.2.1 Aberdeen Test Center (ATC)

The ATC Electromagnetic Test Facility, located at Aberdeen Proving Ground, MD, is a large, free standing shielded enclosure that will accommodate combat vehicles, artillery, tractor trailers, portable shelters, electric power generation equipment, and materials handling and construction equipment. The facility size and structural integrity allow testing of large heavy pieces of equipment and complete systems as well as bench testing of components and systems in a noise-free environment. The facility has a double-walled design that provides a high degree of attenuation to magnetic, electric, and plane wave fields to assure excellent isolation from the outside EME. A series of dolly-mounted anechoic RF absorber panels are used to improve the reflection characteristics of the chamber. The facility contains state-of-the-art instrumentation, ancillary equipment, support facilities, and experienced personnel needed to conduct EMI tests in accordance with both military and commercial standards. It currently has the capability to conduct tests in accordance with the following E3 military and commercial standards and has been certified as an acceptable test facility that meets European Certification Laboratory approved standard requirements.

- MIL-STD-461 and 464,

- SAE-J551 and SAE-J1113,

- C.I.S.P.R. Publication 16, *Specification for Radio Interference Measuring Apparatus and Measurement Methods,* and

- C.I.S.P.R. Publication 22, *Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.*

C.1.2.2 Redstone Technical Test Center (RTTC)

RTTC, located at Redstone Arsenal AL, is a comprehensive test facility that can be utilized for E3 testing of tactical missiles and missile platform system. The E3 Test Branch provides a full spectrum of support to the Aviation and Missile Command Program Executive Officers and PMs, as well as other DoD Agencies and contractors. Among the comprehensive E3 test capabilities described below are the DoD unique capabilities to conduct lightning effects testing on live missiles and munitions.

C.1.2.2.1 Electromagnetic Interference Test Facility

The EMI test facility consists of a 13-feet by 30-feet double-shielded, copper screen room, divided into a test and a control room. The facility is capable of measuring emissions and susceptibilities during subsystem/equipment tests as required by MIL-STD-461. To ensure that there are no problems when assembled into a weapon system, items may be tested to determine the EM effects between subsystems, the effects of subsystems upon external systems, and the effects of external systems upon the subsystem.

C.1.2.2.2 Electromagnetic Radiation Test Facility

This facility provides continuous wave (CW), amplitude modulation, frequency modulation, and pulse modulation testing with several subsets of antennas covering 2 MHz to 40 GHz. Testing is conducted at outdoor ranges as well as in a 40-feet wide, 70-feet long and 22-feet high anechoic chamber which incorporates a below ground fume removal duct system to allow operational testing of ground vehicles. Test items up to 1,000 pounds, such as missiles in simulated free-flight environments, can be positioned in azimuth (full 360 degrees of rotation) and either pitch or roll (± 90 degrees). The facility also contains a 360 degrees of rotation turntable capable of accommodating a vehicle the size of an M-270 Launcher. RTTC also has facilities and methods for the testing of classified hardware up to the SECRET- SPECIAL ACCESS REQUIRED level.

C.1.2.2.3 Lightning Test Facilities

Lightning testing at RTTC is divided into two categories, direct-strike and near-strike tests. Test criteria are contained in MIL-STD-464 and RTTC Technical Report TR-RD-TE-97-01. Lightning simulation generators capable of generating up to 3.6 million volts and 200,000 Amps are used for these tests. Direct-strike test criteria are required for weapon system safety and to prevent permanent damage to electronic components. Near-strike lightning tests are required primarily for protection of EIDs and electronic components from detonation, burnout, destruction, and so forth, particularly during a launch sequence or when the electronics are active. Testing is conducted on both inert and live tactical missile systems. The RTTC lightning test capabilities consist of several distinct test facilities.

- <u>The Inert Lightning Test Facility</u> is utilized for instrumented and go/no-go testing of systems limited to class 1.4 explosives.

- <u>The Hazardous Lightning Test Facility</u> is comprised of two facilities that are tailored for test object size and explosive quantity. A Small System Lightning Test Stand is utilized for testing live, tactical, man-portable, and other small missile items. A Large System Lightning Test Stand is utilized for testing large, live, tactical missile systems and is currently limited to 100 pounds of Class 1.1, 5,000 pounds of Class 1.2, 15,000 pounds of Class 1.3, and unlimited Class 1.4 explosives. The Hazardous Lightning Test Facility is capable of testing live, tactical missile systems in the lightning environment. It also has a portable environmental conditioning chamber capable of conditioning vehicles to both "hot" and "cold" temperature extremes.

C.1.2.2.4 Electromagnetic Pulse Facility

The EMP test facility provides a sub-threat, high altitude, EMP environment to determine weapon system safety and survivability and to analyze system EMP effects.

C.1.2.3 White Sands Missile Range

The Directorate for Applied Technology, Test and Simulation performs E3 testing at the Electromagnetic Radiation Effects Facility at WSMR and at Kirtland Air Force Base (AFB) in Albuquerque, NM. The test facility provides outdoor testing for combat systems, helicopters, and various types of combat sup-port and combat service support equipment. A lightning test facility is under construction.

C.1.2.3.1 Electromagnetic Interference Facilities

These facilities are capable of performing the entire battery of MIL-STD-461 tests. Testing is conducted in one of two special facilities designed to reduce ambient background noise to a minimum. The first is an 18-feet long by 11-feet wide by 5-feet high anechoic chamber used for testing small items. The second is a large, shielded test cell with interior dimensions of 60-feet long by 40-feet wide by 40-feet high. This test cell is used to test large items and those items requiring high capacity air intake and exhaust. Two large intake fans and two large exhaust fans allow such items as the M1 Abrams tank to be tested in a fully operational mode with engines running.

C.1.2.3.2 Electromagnetic Radiation Facilities

Using any or all of five separate transmitters, outdoor test facilities provide both RADHAZ and inter-system EMI/EMC testing. The five available transmitters cover frequencies from 100 kHz to 18 GHz, at power levels to 50 kW, depending upon the specific transmitter and test environment. Maximum field intensities are typically on the order of 200 V/m. Higher field levels can be achieved depending on frequency, size of the item under test, and the relative position of the item.

C.1.2.3.3 Electromagnetic Pulse Facilities

EMP testing is performed at Kirtland AFB using one of several threat level EMP simulators, either the Horizontally Polarized Dipole Facility or the Vertically Polarized Dipole Facility. These facilities can produce both horizontally and vertically polarized electric field strengths from 0.1 to 100 kV/m. Other facilities include a lightning simulator, a vertically polarized bounded-wave EMP simulator, and a Direct Drive Laboratory for the direct application of controlled electrical overstress signals into electronic components.

C.1.2.4 Ft. Huachuca - Electronic Proving Ground (EPG)

C.1.2.4.1 Blacktail Canyon Test Facility

EPG has a capability to perform EMI/EMC testing in accordance with MIL-STD-464 and 461 for DoD platforms/systems and subsystems/equipment as well as various commercial EMI/EMC standards tests that may be required by the customer. The facility is located at the Blacktail Canyon area of Ft. Huachuca, AZ, a RF-isolated area with a relatively low ambient RF level. This location is ideal for open-field EMC/EMI testing efforts. Test equipment and fixtures necessary to conduct testing include three automated receiver systems, 20 Hz to 40 GHz, which can be used to perform radiated and conducted emission measurements of systems, subsystems, and components. The facility instrumentation suites provide three automated EMI data collection suites and two integrated EMI susceptibility test systems allowing RF illumination of items under test from 10 kHz to 40 GHz at field levels greater than 200 V/m, depending upon test frequency. In addition to the fixed facility, EPG has readily available portable systems, offering worldwide on-site support to the customer.

C.1.2.4.2 Electromagnetic Environmental Test Facility

Located in the main post area of Ft. Huachuca, this test facility is a complex of experimental and analytical capabilities that can be used to measure and analyze system performance in a broad spectrum of intended EME. The facility assesses the ability of C4I systems to operate in their intended EME and to assess the influence of the system on the EME. This function is accomplished by a combination of M&S, hardware-in-the-loop testing, and field-testing. It is also responsible for developing and maintaining databases of equipment characteristics and simulated tactical deployments to support EMC and EMV analyses and Army management of the electromagnetic spectrum.

C.1.2.4.3 Virtual Battlefield Environment Facility

This is a closed-loop facility that generates actual RF and digital message signals to provide a realistic EME to a item under test. It emulates signals that the test item would expect to see in its intended operational EME. These signals are computer-controlled and can represent the EME in any part of the world. The facility can create an electronic battlefield capable of simulating up to 1024 non-communications emitters (radar and sensors) in the 0.5 - 18 GHz frequency range and 32 communications emitters in the 0.5 - 500 MHz frequency range. These can be either friendly or enemy emitters. An enhancement is the Joint Tactical Information Distribution System (JTIDS) network linker unit. The network linker consists of a matrix switch that receives input from up to ten JTIDS terminals. The test facility provides the simulated EME to the JTIDS network. This allows the JTIDS network to be tested in a virtual EME without going to the field.

C.1.2.4.4 Virtual Electromagnetic C4I Analysis Tool

EPG has developed a set of integrated computer programs called the Virtual Electromagnetic C4I Analysis Tool to perform analysis and evaluation of C4I systems in their intended operational environments. The principal thrust is to provide C-E system analysis capabilities embedded in a user-friendly graphical user interface. It can overlay results using Defense Mapping Agency digital terrain and digitized raster graphics maps, or commercial-off-the-shelf graphics visualization and statistical analysis tools. The tool gives engineers and communicators a geographic information system that supports creation of simulated tactical deployments, military symbols, map displays for magnetic media or compact discs, line-of-sight profiles, and terrain high points display. The measures that can be calculated include electromagnetic propagation path loss, radio horizon, received signal level, signal-to-noise, ration, bit error rate, electric field, percentage of time available, fade, and dilution of precision values for global positioning system predictions. A foliage propagation model is available for analyzing attenuation of link communications., as are a number of other propagation models.

C.1.2.4.5 Mutual Interference Environments

For technical and operational tests, EPG can provide realistic battlefield conditions simulating "dirty" EME caused by mutual EMI of electronic equipment. This environment provides a virtual "friendly jamming" environment for operational or technical testing of C-E within an approved operational scenario. The effects of several thousand emitters, all sharing a common hop-set, can be simulated with as little as 100-200 actual radios through the use of propagation path loss models, specially designed automatic keyers, and emitter placement algorithms.

C.1.3 Tank Automotive Command - Armaments Research, Development & Engineering Center (TACOM-ARDEC)

The E3 team at TACOM-ARDEC provides E3 technical support to local, DoD, and Foreign developers of systems and equipment. Guidance is provided to ensure that developmental systems will not be susceptible to EME levels encountered during the system life cycle. The E3 team has several research and engineering facilities to study and evaluate instrumented or live weapon systems against a wide range of severe man-made or natural EME. Additionally, the E3 team provides technical and acquisition support to the Army Fuse Safety, Type Classification, and Material Release Boards, and the Foreign Intelligence Office and Tri-Service HERO Committee. A description of the facilities follows.

C.1.3.1 HERO Research and Engineering Facility

The HERO facility is designed to perform RF studies on Army-developed weapon systems in accordance with MIL-STD-464. All HERO studies are performed inside a heated and air-conditioned shielded anechoic chamber. High power transmitters and TEM cells cover frequencies from 100 kHz to 40 GHz at power levels to 30 kW, with maximum field intensities on the order of 200 V/m. The facility can be used for RF susceptibility investigations, RF shielding measurements, in-band and out-of-band RF threat simulations, as well as specialized projects involving millimeter weapon technology.

C.1.3.2 Electromagnetic Radiation, Operational Test Facility

Testing at this facility is performed inside an anechoic chamber using the same RF transmitters, antennas, and fiber optic instrumentation as in the HERO facility described above. Studies are performed in accordance with the criteria in MIL-STD-464.

C.1.3.3 EMI Test Facility

The E3 team maintains laboratory capabilities for EM emission studies to evaluate Army electronics and electrical systems and subsystems in accordance with MIL-STD-461. Testing is conducted inside an RF-shielded anechoic room designed to reduce the ambient background noise to a minimum. The room size and structural integrity allow studies from small to mid-size pieces of equipment in a noise-free environment.

C.1.3.4 Helicopter Electrostatic Discharge Test Facility

Helicopter ESD studies are performed in accordance with the criteria in MIL-STD-464 and MIL-STD-331. Instrumented, as well as go/no-go studies are conducted on inert and live tactical ammo systems in their shipping/storage and tactical configurations. Studies are also conducted on live weapon systems and electronic subsystems to determine detonation, upset, burnout and destruction levels.

C.1.3.5 Personnel Electrostatic Discharge Test Facility

Personnel ESD studies are performed in accordance with the criteria in MIL-STD-464 and MIL-STD-331. Studies are conducted on live weapon systems and electronic subsystems to determine detonation, upset, burnout, and destruction levels. Instrumented and go/no-go studies are conducted on inert and live tactical ammo systems in their handling configuration.

C.1.3.6 EMP Test Facility

The EMP facility uses a vertically-polarized, parallel plate chamber to simulate a HEMP environment which is used to determine weapon system safety and survivability and to perform hardening evaluations. The facility is capable of producing peak electric fields of 50 kV/m, which meet the unclassified EMP threat in accordance with MIL-STD-461 and MIL-STD-464.

C.1.3.7 Bruceton and Langley Test Facility

This facility performs No-Fire and All-Fire statistical values of EIDs such as detonators, primers, and actuators. Constant current and capacitor discharge characteristics are determined that can handle class 1.3 and 1.4 explosives. Test data is computer-generated using an approved MIL-STD-1576 computer program.

C.1.4 Aviation and Missile Command

RTTC facilities provide test and experimental support to the Missile Research Development and Engineering Center. Facilities to support the testing of Army aircraft are provided by the Naval Surface Warfare Center, Dahlgren Division (NSWCDD) located in Dahlgren, VA and the Naval Air Warfare Center, Aircraft Division (NAWCAD) located in Patuxent, MD.

C.1.5 Communication and Electronics Command (CECOM)

CECOM Research and Development Engineering Center, Space and Terrestrial Communication Directorate, Wireless Network Division provides E3 engineering expertise to implement Army E3 policy. Design and test guidance are provided to CECOM developers. A limited EMI/EMC test facility is available to evaluate fixes, as necessary, and to evaluate CI/NDI. SM and frequency allocation support is also provided for all CECOM developments and procurements.

C.1.6 US Army Center for Health Promotion and Preventive Medicine

The Center provides HERP support and radiation protective studies in support of health hazard assessments, safety assessments, and safety releases. Teams are available to assess compliance with applicable DoD and Army regulations regarding human exposure to RF radiation.

C.1.7 Army Points of Contact

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C.2 Navy Facilities and Capabilities

C.2.1 Naval Aviation System Team

C.2.1.1 Patuxent Naval Air Station

The Naval Air Systems Command (NAVAIR) Code 4.1.7, E3 Division, provides engineering expertise for addressing the E3 requirements of aircraft systems, subsystems and support equipment in the naval aviation's friendly and hostile operational EME. This support encompasses aircraft, aircraft weaponry, aircraft subsystems, ground support equipment, naval shore facilities, and air-capable ship installations. The Division manages frequency spectrum allocation coordination and efforts to control deliberate and non-deliberate EMR, to avoid breach of security and detection by hostile forces, and to avert pollution of the spectrum by friendly users. E3 engineers analyze and solve fleet-reported E3 problems. Division personnel cover a wide range of electromagnetic disciplines dealing with EMI, EMC, EMV, RADHAZ, lightning, EMCON, high transient threats, and p-static.

NAWCAD Code 5.1.7 at Patuxent River, MD, supports E3 research, development, and T&E. This support encompasses supplying the test facilities and capabilities to conduct T&E of aircraft, aircraft weaponry, aircraft subsystems, and ground support equipment. Division personnel cover a wide range of electromagnetic disciplines that deal with EMI, EMC, EMV, EMP, high transient threats, lightning, p-static, EMCON, and RADHAZ.

The Mid-Atlantic Area Frequency Coordination Office (MIDLANT AFC) is a component of the Chesapeake Test Range for electromagnetic SM coordination for U.S. Navy and U.S. Marine Corps Commands in the Middle Atlantic Area. It is the frequency manager for NAWCAD and reports operationally to Commander in Chief, Atlantic Fleet. The mission of the MIDLANT AFC is to ensure effective and compatible authorized use of the radio frequency spectrum by all of the NAWCAD activities, tenants and their contractors. To accomplish this mission, the MIDLANT AFC is authorized direct coordination with Government and non-Government activities throughout and adjacent to the Middle Atlantic area. For interference detection and resolution, the MIDLANT AFC has a lightweight, portable unit that can intercept from 0.5-2036 MHz and provide a direction-finding coverage between 1-1400 MHz. Also, two formal, state-of-the-art frequency monitoring and interference control facilities are under development: one mobile and one fixed. The facilities will provide spectrum coverage from 2 MHz to 18 GHz, with a receiver system, spectrum analyzer, pulse counter, recorder, and direction finder accurate to within one degree.

C.2.1.1.1 Air Combat Environment Test and Evaluation Facility (ACETEF)

The ACETEF is a fully integrated, ground test facility allowing full-spectrum T&E of aircraft and aircraft systems in a secure, controlled, engineering environment. The state-of-the-art facility uses simulation and stimulation techniques to provide test scenarios that will reproduce actual combat conditions. Aircraft systems are deceived through a combination of simulation by digital computers and stimulation by computer-controlled environment generators that provide radio frequency, electro-optical, and laser stimuli that closely duplicate real signals. The ACETEF complex has a variety of individual labs that, when networked, can simulate virtually all aspects of aircraft operations, and include:

- Shielded Hangar and Anechoic Chamber,
- Simulated Warfare Environment Generator,
- Electronic Warfare Integrated Systems Test Laboratory,
- Threat Air Defense Laboratory,
- Communication, Navigation, Identification Laboratory,
- Offensive Sensors Laboratory,
- Manned Flight Simulator, and
- Aircrew Systems Evaluation Facility.

C.2.1.1.2 Shielded Hangar and Aircraft Anechoic Test Facility Anechoic Chamber

Located with access to three runways, the Shielded Hangar provides a specialized environment for testing that includes the Aircraft Anechoic Test Facility. Large enough to accommodate multiple large aircraft, the Shielded Hangar has interior walls and doors covered with wire mesh and one anechoic wall. These features allow E3 testing and EW suite integration. Inside the hangar, an anechoic chamber provides a secure and realistic test environment for system stimulation for tactical aircraft. The hangar also supports lightning and p-static testing on full-scale test articles. The anechoic chamber, measuring 100 feet by 60 feet by 40 feet, can hold tactical aircraft and helicopters.

C.2.1.1.3 Advanced Systems Integration Laboratory Large Anechoic Chamber

The Large Anechoic Chamber provides a secure test environment for system stimulation of multiple tactical-sized aircraft via two 40-ton hoists, or a large aircraft the size of an E-6 or B-2. The anechoic chamber, measuring 180 feet by 180 feet by 65 feet, and can hold tactical aircraft and helicopters as well as large aircraft in a secure test environment utilizing the full capability of ACETEF. The Large Anechoic Chamber is adjacent to the shielded hangar and is connected to the Aircraft Anechoic Test Facility described in C.2.1.1.2 above for multiple chamber connective operation.

C.2.1.1.4 Anechoic Chamber

The enclosed chamber is used for T&E of antenna systems, antenna patterns, radar cross section measurements, and partial, full-scale aircraft mock-ups. Data may be obtained from scale model aircraft of missiles via automated measurements in an anechoic chamber. The radar scattering return is measured from targets ranging from scale model aircraft to antennas and other components. Diagnostic test procedures are used to indicate major flare spots to enable development of treatments to alter the scattering return. The indoor anechoic chamber is 40 feet by 20 feet by 20 feet with a 6-foot cylindrical quiet zone.

C.2.1.1.5 Electromagnetic Environment Generating System (EMEGS)

The EMEGS is used to generate operational EME. Testing is conducted in the shielded hangar or anechoic chamber, or outside on either the Naval Electromagnetic Radiation Facility steel ground plane or on the shielded hangar apron. The facility simulates the worldwide Fleet operational EME and evaluates effects on an aircraft's critical functions, mission systems, and vehicle systems. It can be used to support intersystem EMC, EMR, HERO, or any type of radiated susceptibility test. The facility supports military and commercial aircraft, unmanned air vehicle, ground support equipment, and air-launched ordnance system testing.

C.2.1.1.6 Electromagnetic Transients Test and Evaluation Facility

This facility provides threat-level EMP, lightning, and p-static testing capabilities. A high performance, fiber optic data acquisition and processing system designed for single-shot, fast rise-time measurements is available to collect data during testing. The High-Voltage Lab supports maintenance, improvements, and the development of new capabilities. The horizontally polarized dipole EMP simulator is used to conduct tests on avionics equipment and weapon systems. The test results help determine the survivability and vulnerability of aircraft systems to the EMP threat. The vertically polarized dipole, which is co-located with the horizontal dipole, also simulates a HEMP environment. It is a free-field simulator that uses a 2 MV pulser to generate a double exponential, vertically polarized field in the test volume.

C.2.1.1.7 Naval Lightning Laboratory

The Naval Lightning Laboratory at Patuxent River provides a test and evaluation capability to address atmospheric effects, including lightning and p-static.

C.2.1.1.8 EMI Laboratory

The primary function of the EMI Laboratory is to provide MIL-STD-461 evaluation capabilities to the Navy and DoD. The laboratory supports a diverse range of projects including hand-held equipment, electrical power systems, crash cranes, aircraft tow tractors, and aircraft and communication shelters. The EMI laboratory also provides services such as engineering analysis, EMI consultation, troubleshooting, fleet support, document review, site survey, EMCON assessment, and other programs that address many of the uncertainties associated with EM measurements.

C.2.1.2 Electromagnetic Interference Laboratory Lakehurst, New Jersey

This laboratory provides a wide range of E3 testing, evaluation, and review, including MIL-STD-461 compliance testing. The lab is used to perform emission tests from 20 Hz to 10 GHz, susceptibility tests from 30 Hz to 18 GHz, radiated susceptibility tests up to 200 V/m, and EMP susceptibility tests for signals up to 10 A line load and 50,000 V/m.

C.2.2 Naval Sea Systems Command (NAVSEA)

C.2.2.1 Naval Surface Warfare Center, Dahlgren Division (NSWCDD)

NSWCDD is the surface Navy's lead laboratory for E3 T&E. Code J50 provides expertise and leadership to ensure the operational effectiveness of Navy and Joint systems exposed to the operational EME. To accomplish this, NSWCDD conducts a multi-faceted program to achieve battle group, platform/system, and subsystem/equipment EMC. NSWCDD participates in all aspects of E3, including the development of new technologies, acquisition, and solving fleet EMI problems. The NSWCDD facilities available to perform E3 evaluations are discussed below.

C.2.2.1.1 Ground Planes

NSWCDD maintains various ground planes that provide a simulated ship deck environment for conducting high power EMV and HERO testing. Transmitters provide the full range of power and frequency to simulate the mission EME, which also can be generated at customer locations/facilities. Supporting instrumentation provides state-of-the-art telemetry data collection and reduction capability. NSWCDD has two unique ground plane facilities that permit evaluation of the effects of a Joint tactical EME upon EEDs and other subsystems/equipment. Aircraft, missiles, gun mounts, and fire control systems can be tested to evaluate their performance in a friendly or hostile operational EME or they can be evaluated to determine their operability during in-service use. These ground plane facilities provide a simulated ship, either weather or flight deck environment, for conducting high power EMV and HERO testing. Transmitters provide the full range of power and frequency to simulate the mission EME. If susceptibility occurs, points of entry, susceptibility thresholds, and solutions are identified. The facilities can provide a wide range of service conditions in which electromagnetic evaluations can be accomplished.

Mobile radar, radio transmitters, and special generators with appropriate antennas for simulating the ship EME are positioned around the edges of the ground planes. The transmitting equipment operates over a frequency range of 2 MHz to 35 GHz, at power levels ranging from 15 kW continuous wave to 3 MW pulse power. Testing can also be conducted at customer facilities using equipment in trailers with the full range of power and frequency to simulate a mission EME.

Also located at NSWCDD is the EMV laboratory, which provides telemetry collection, data reduction, and analysis for the ground planes, anechoic chamber, and mode-stirred chamber (MSC). The individual test sites are connected to the laboratory through state-of-the-art, fiber optic data links, which allow for EMI-free data collection.

C.2.2.1.2 Anechoic Chamber

This facility provides a controlled, reflection-free environment for conducting EMV tests and evaluation on a broad range of systems. The chamber is a shielded enclosure within which missiles and other test items are immersed in a simulated operational (hostile and friendly) EME. It provides a full-threat level test chamber capable of evaluating electronic and weapon systems in their intended operational EME from 150 MHz through 60 GHz.

C.2.2.1.3 Mode Stirred Chamber (MSC)

The MSC provides specialized reverberation conditions for system susceptibility and shielding effectiveness testing. The MSC is a reverberation chamber developed by NSWCDD that provides a time-efficient, cost-effective way to evaluate the performance of large equipment using a shielded enclosure in which very high fields can be safely generated for performing E3 testing in a simulated "real world," near-field EME. The MSC is used to conduct shielding effectiveness measurements of enclosures, planar materials, gaskets, cable assemblies (including cables with associated connectors) and other shielding materials. The MSC is also used to make coupling measurements, radiated emissions measurements, HERO testing, and EMV testing of systems, subsystems, and components. Amplifiers are available in the facility to transmit swept or discrete continuous wave signals from 100 MHz - 18 GHz into the chamber. High power cavities and magnetrons from the ground planes can be positioned adjacent to the building and the power routed into the chamber.

C.2.2.1.4 Naval Ordnance Transient Electromagnetic Simulator

This simulator creates an EMP environment similar to that produced on the Earth's surface from a high-altitude nuclear burst. The facility provides a threat-level HEMP to evaluate susceptibility of naval weapons and other systems having EMP survivability requirements, to verify EMC of systems, and to perform EMP hardening evaluations. The facility is capable of producing simulated HEMP and peak electric fields of 50 kV/m which meet the unclassified EMP threat of MIL-STD-461, and can satisfy major elements of the classified MIL-STD-2169. The facility can also be used to provide developmental or design validation by testing peak field strengths of up to 200 kV/m.

C.2.2.2 Naval Surface Warfare Center, Crane

The Naval Surface Warfare Center, at Crane, Indiana, maintains 2 anechoic chambers.

C.2.2.3 Electromagnetic Engineering (EMENG) System

The EMENG is the NAVSEA standardized tool that supports design decisions for the purposes of optimizing the performance of topside electromagnetic radiating systems. The tool provides the means to predict the topside EME and to assess the impact of EMI on system performance. The EMENG consists of numerous engineering models and databases including the Blockage Analysis Model, Ray Tracing and Casting Model, Georgia Tech Multiple Obstacle Code, Georgia Tech Coupling Model, and the Numerical Electromagnetic Code with the Numerical Electromagnetic Engineering Design System Workstation.

C.2.3 Space and Naval Warfare Systems Command (SPAWAR)

SPAWAR has developed the following capabilities:

- Automated Spectrum Planning, Engineering, Coordination, and Tracking System (ASPECTS) which provides automated frequency management and Battle Group communications planning capability for Navy and Marine Corps personnel worldwide. ASPECTS has the following modules:
    - Frequency Management Module
    - Communications Planning Module
    - High Frequency Prediction Module
    - Spectrum Certification Module
    - Electromagnetic Compatibility Analysis Program

- The Battle Force EMI Evaluation System (BEES) was developed as an operational planning and performance assessment tool. BEES quantifies the effects of EMI on Battle Force performance. It provides the capability to systematically assess the impact of proposed or developmental systems on the effectiveness of the Battle Force. Its strength is its ability to evaluate many systems against any systems operating in the environment, including military, commercial, and international emitters. In addition, BEES has the capability to evaluate new equipment in a dynamic EME.

C.2.3.1 SPAWAR Systems Center Charleston (SSC Charleston)

The E3 Branch Code 32 at SSC Charleston provides E3 services to Navy, DoD, and other customers. Specific functions include conducting EMI investigations, recommending preventive and corrective measures for EMI and RADHAZ, performing EMC and RADHAZ surveys and analyses, conducting electromagnetic susceptibility testing on electronic equipment, and providing E3 certification for facility planning documents. The Branch maintains laboratory test capabilities for MIL-STD-461 as well as commercial test procedures. A wide variety of tests can be performed, including radiated susceptibility testing, transient testing (conducted and radiated), and EMP.

C.2.3.2 SPAWAR Systems Center San Diego (SSC San Diego)

Code 825 at SSC San Diego provides products, services, and support in the following areas:

- Electromagnetic modeling, simulation, and interference mitigation, and

- Systems analysis.

This division maintains and manages the following capabilities:

- Antenna Characterization Range,

- Antenna Pattern Range,

- Composite Materials Test Facility,

- GHz Transverse Electromagnetic Mode Cell,

- Multifunction Electromagnetic Radiation System Laboratory, and

- Numerical Modeling Facility.

Project areas supported include the design, development, integration, evaluation, and modification of communications, surveillance, and other electromagnetic systems. The following are examples of tasks that are performed in those project areas:

- Antenna designs and placements,

- EMP and survivability testing,
- EMI and IMI testing,
- E3 and EME analyses, and
- Shipboard design, including topside arrangement studies, antenna radiation patterns, complex impedance/isolation measurements and predictions, and EMP protection.

C.2.4 Other Navy Activities

C.2.4.1 Naval Research Laboratory (NRL)

C.2.4.1.1 Advanced Technology Chamber

The NRL Advanced Technology Chamber is a welded-aluminum, shielded room that is 5.33 meters by 4.64 meters by 2.73 meters and is used to conduct research on mode stirring techniques for assessment of E3 to Navy platform electronic systems. The chamber, through a rotating aluminum stirrer, introduces a large number of different modes that characterize the distribution of the electric and magnetic fields from 200 MHz through 40 GHz. The mode stirring provides for a randomly polarized field environment. The randomly polarized field allows a test artifact to be subjected to a statistically uniform EME providing for repeatability in measurements. Large electric field levels are possible with modest amounts of input power.

C.2.4.1.2 Compact Range Facility and Anechoic Chamber

The NRL Radar Division operates and maintains a Compact Range Facility and a smaller anechoic chamber. The Compact Range, which produces far field conditions in a limited space, enables users to characterize antennas that would normally need thousands of feet of space for proper measurements. These facilities are used to measure antenna characteristics, such as beam width, gain, sidelobe levels, and polarization over a frequency range from 2 to 100 GHz. This range can also be configured to measure the radar cross section of antennas or other targets from 2 to 18 GHz. The largest object that can be measured in the Compact Range Facility must fit into a cylinder that is 8 feet in diameter and 8 feet in length. Below 6 GHz, the diameter drops to 6 feet.

C.2.4.2 Naval Undersea Warfare Center (NUWC) Newport

NUWC at Newport, RI, maintains an anechoic chamber and specialized, low frequency laboratory test capabilities.

C.2.5 Navy Points of Contact

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C.3 U.S. Marine Corps (USMC) Facilities and Capabilities

C.3.1 USMC Logistic Base, Maintenance Center, Barstow, CA

C.3.1.1 Mobile Electromagnetic Environmental Effects Shelter

The Shelter was designed to provide for detection of a wide range of externally and internally radiated and conducted emissions. It is capable of detecting externally and internally generated EM emissions in pulse, CW, modulated CW, and bursts of CW waveforms. The E3 system operates over a wide range of frequencies and received power levels. Test teams utilize the E3 system to solve operational E3 problems.

C.3.2 Marine Corps Points of Contact

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C.4 Air Force Facilities and Capabilities

C.4.1 Air Armament Center

C.4.1.1 Preflight Integration of Munitions and Electronic Systems (PRIMES)

The PRIMES Test Facility performs installed systems testing of air-to-air and air-to-surface munitions and electronics systems on full-scale aircraft and land vehicles. The tests include system level integration performance, weapon system effectiveness via the Guided Weapons Evaluation Facility/PRIMES Link, and electromagnetic compatibility and vulnerability measurements.

PRIMES has the following capabilities:

- 100-dB, RF-isolated, anechoic chamber with a hoist lift capacity of 40 tons and capable of testing all current U.S. Air Force and Navy fighter aircraft and helicopters

- Hanger - a sheltered, non-anechoic testing environment with access to all facility simulation and instrumentation capabilities

- Outdoor Ramp – an open-air flightline area for testing of large aircraft, with access to all facility simulation and instrumentation capabilities.

- Test Stations - shielded laboratories for subsystem level testing of fighter and bomber electronics and weapon systems

- EMI/EMC Chamber - semi-anechoic shielded enclosure for testing to MIL-STD-461 and commercial EMI standards

The major PRIMES modeling and simulation systems include:

- Real-time six-degrees-of-freedom flight motion simulator for shooter and target motion dynamics

- Four target, closed loop radar target simulator with dynamic radar cross section, jet engine modulation, electronic countermeasures, and clutter signatures

- 6174 open loop, multiplexed threat radar emitters

- Weapons and aircraft simulators

- Two, 10-channel, differential Global Positioning System constellations and jammers

- Test instrumentation systems for umbilical and telemetry analyses.

C.4.2 Air Force Research Laboratories (AFRL)

C.4.2.1 Information Directorate

The Newport Research Facility is used to evaluate antennas and antenna systems in a far-field "free space" environment, to determine radiation pattern changes due to airframe effects, for the measurement of antenna-to-antenna isolation, and to support advanced antenna measurement technology development. This facility provides the capability to conduct accurate measurements of antennas installed on airframes (such as F-4, F-111, A-10, F-15, F-16, F-22, F-14, C-12, RAH-66, B-1 sections), complex multi-beam and phased arrays, advanced ultra low sidelobe arrays and multiple antenna systems.

The Stockbridge Research Facility is located atop a 2300-foot hill. Real property consists of a 5800-square foot laboratory and 4000-square foot storage area on 300 acres of land. The facility uses a modified AN/FPS-35 pedestal to mount and rotate large airframes such as the B-52, KC-135, AH-1, C-130, and B-1B. An antenna pattern measurement system is used to evaluate the performance of large platforms. The system provides the capability for measuring antenna patterns and antenna isolation (coupling) on large airframes mounted in an upright or upside down configuration. Airframe modifications can be performed on-site to simulate numerous aircraft types and configurations.

The Anechoic Research Facility provides the capability to simulate, measure, and improve the EM performance of weapon, communication, command, control, computer, and intelligence systems in the EME in which they operate. It also performs electromagnetic effects research investigations of antenna/aircraft EM interactions and EM characterizations of advanced technologies. Intra-system coupling and isolation can be measured. The measurement area consists of two EM anechoic chambers, two reverberation chambers, RF sources, and instrumentation. The two anechoic chambers (40ft x 32ft x 48ft and 12ft x12ft x36ft) provide a “free space” EME for detailed evaluation. A reverberation chamber (32ft x17ft x12ft) provides a "quick look," evaluation capability for assessments of RF coupling and shielding effectiveness.

C.4.2.2 Sensors Directorate

The EMI Test Laboratory is capable of performing all of the standard test methods of MIL-STD-461, including 200 V/m evaluations up to 18 GHz. The primary test chamber is 18 ft x 20 ft and is semi-anechoic in accordance with MIL-STD-461. The adjacent control room is shielded and is 12 ft x 16 ft. Available power is 115 Volt, three phase, 400 Hz; 28 Volt DC; and 115 Volt, single phase 60 Hz.

C.4.3 Air Force Flight Test Center (AFFTC)

C.4.3.1 Benefield Anechoic Facility

This facility supports installed systems testing for aircraft and avionics test programs requiring a large, shielded anechoic chamber with RF absorption capability that simulates free space. The chamber is 264 ft x 250 ft x 70 ft.

The facility is used to investigate and evaluate anomalies associated with EW systems, avionics, tactical missiles and their host platforms and is suitable for EMC evaluations where isolation from the external EME is required. Tactical-sized, single or multiple, or large vehicles can be operated in a controlled EME with emitters on and sensors stimulated while RF signals are recorded and analyzed. The largest platforms tested at this facility have been the B-52 and C-17 aircraft. It also supports testing of other types of systems such as spacecraft, tanks, satellites, air defense systems, drones, and armored vehicles.

Test equipment generates signals with a wide variety of characteristics, simulating unfriendly, friendly, and unknown surface-based, sea-based, and airborne systems. With the combination of signals and control functions available, a wide variety of test conditions can be emulated. Many conditions that are not available on outdoor ranges can be easily generated from the aspect of signal density, pulse density and number of simultaneous types.

C.4.4 738 Engineering Installation Squadron

The squadron provides measurement and specialized engineering services to include communications circuit analysis, EMC, RADHAZ measurements, interference resolution and direction finding, shielding effectiveness measurements, and EMP hardness verification testing. The squadron has several mobile vans with telescoping antenna masts and spectrum analysis suites equipped to make sophisticated measurements on site. Examples of past projects are evaluating the EME in the vicinity of large ground radar systems and ensuring that protective systems for ground communications shelters provide the required levels of performance against the EMP threat.

C.4.5 Air Force Points of Contact

Air Force Frequency Management Agency (AFFMA)
2461 Eisenhower Ave, Hoffman I, Suite 1203
Alexandria, VA 22331-1500
- For E3 Issues (Maj. D. Pierce)
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Air Armament Center (AAC)
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Air Force Flight Test Center (AFFTC)
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Air Force Research Laboratory (AFRL)
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Space and Missile Systems Center (SMC)
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Los Angeles, CA 90009
(213)363-1880

C.5 Joint Spectrum Center (JSC)

The JSC mission is "to ensure the effective use of the electromagnetic spectrum in support of National security and military objectives." There are three objectives associated with this mission for which M&S and database resources are required: spectrum planning, systems acquisition support, and operational support.

- Spectrum planning services and capabilities support the warfighter's spectrum requirements by assisting in spectrum policy planning, SC, and frequency assignment planning.

- Acquisition support services and capabilities optimize the performance of systems in their intended operational EMEs while minimizing system acquisition cost and schedule.

- Direct operational support to the warfighter provides SM and interference resolution support to the warfighting CINCs and Military Departments.

Analyses in support of these objectives have as their goal an evaluation of the impact of E3 on C4I, Surveillance, and Reconnaissance (C4ISR) systems, personnel, ordnance, or fuel. The application of E3 analyses may be to identify optimum spectrum use, operational constraints, or system design alternatives for C4ISR systems. For personnel, ordnance, and fuel, predictions of RADHAZ distances are often required. E3 analyses must identify not only impacts to system performance alone, but also the impact of system performance degradation in military missions, or, mission effectiveness. These analysis requirements define the M&S tools of the JSC. Two such tools are described below.

C.5.1 Joint E3 Evaluation Tool (JEET)

JEET examines potential E3 interactions between equipment scheduled for operational testing and existing equipment in the DoD inventory. It identifies the systems in the DoD inventory with the potential to interfere with the subject equipment under test in a Joint EME. JEET uses a pre-built database consisting of operational mode records downloaded from the JSC databases. JEET calculates interference to noise and power density.

C.5.2 JSC Ordnance E3 Risk Assessment Database (JOERAD)

The JOERAD software system aids in determining ordnance safety for any collection of ordnance deployed in any Joint operational environment. It supports the performance of HERO impact assessments, which are used to assist management of the conflict between ordnance and RF emitters employed in a Joint operational exercise. JOERAD contains the ability to view, query, and maintain stored HERO susceptibility data.

In the Susceptibility module, the HERO information includes identification and administration of any ordnance item, the EID data associated with threat ordnance, and the Maximum Allowable Environment (MAE) for the ordnance in a set of prescribed frequency ranges. To aid in the risk impact assessment of ordnance, JOERAD also contains the ability to view and query nominal characteristics of emitters. The Equipment Characteristics Module of JOERAD provides system, component, and antenna parameters and works with the Susceptibility module during impact assessment processing. The complete JOERAD system contains an Integration Module to further aid in the risk assessment process by comparing ordnance MAE data with the emitter data for operational platforms.

C.5.3 JSC Points of Contact

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Annapolis, MD 21402-5064
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  (JOERAD: Mr. M. Grenis)
- SM IT Division (J6) (410) 293-4956
  (Mr. T. Diep)
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  (Mr. M. Williams)

web site: www.jsc.mil

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APPENDIX D

GUIDE FOR THE USE OF

COMMERCIAL STANDARDS

CONTENTS

D.1 General

On June 29, 1994, the Secretary of Defense issued a Directive requiring the military to use performance-based requirements in procurements and to apply commercial specifications and standards whenever possible. This Appendix is intended to aid acquisition personnel to assess the suitability of using equipment qualified to commercial EMI/EMC standards in specific military applications. This goal is consistent with the direction contained in DoDR 5000.2-R and Handbook SD-2.

This Appendix should be used in conjunction with the report resulting from EPS-0178. The EPS report provides the results of detailed comparisons between major National and International commercial EMI/EMC standards and MIL-STD-461E. Differences in limits, frequency ranges, and test procedures were identified, and their potential significance was discussed in the study report. In addition, guidance was provided in the report on judging the acceptability of a particular commercial standard for a specific military application.

D.2 Applicability Considerations

In general, the factors that need to be considered in evaluating the applicability of commercial equipment for military applications include the following:

- System performance requirements,
- Impact on mission and safety,
- Operational EME,
- Platform installation characteristics, and
- Equipment EMI characteristics.

Given the complexity and number of factors that must be considered in the overall evaluation process, the process may require the assistance of E3 personnel.

D.3 Detailed Requirements

D.3.1 Rationale for Requirements

The motivation behind the development of military and commercial EMC requirements is similar. Both are concerned with controlling emissions from equipment that may couple to other equipment with very sensitive interfaces, particularly antenna ports. Also, both are concerned with providing adequate immunity against electromagnetic disturbances that may be present in the environment, such as electromagnetic emissions, both intended and unintended, electrical transients, and power line voltage distortions. The reason for the distinctions between the military and commercial requirements occurs because of the military platform types, particularly ships, aircraft, ground vehicles, space vehicles, and ordnance. Typically, these platforms have a heavy concentration of equipment including high-power transmitters and very sensitive receivers. Submarines and certain aircraft may also have special requirements because of the frequency ranges of many of their subsystems/equipment.

D.3.2 Evolution of Requirements

D.3.2.1 Military

The military first established EMI emission requirements for equipment in 1945 with the issuance of JAN-I-225. Conducted and radiated measurements were imposed over the frequency range of 0.15 to 20 MHz. The first susceptibility requirement (expressed in terms of "immunity" in most commercial standards) was introduced in 1950 with the publication of MIL-I-6181. As electronics became more sophisticated and applications more widespread, the requirements evolved and expanded significantly over time. A variety of documents were issued with broader frequency ranges for emission requirements and an increased emphasis on various types of susceptibility requirements. In 1967, many of these documents were canceled or consolidated with the issuance of MIL-STD-461/462. In the latest version, these two documents have been merged into one, MIL-STD-461E.

D.3.2.2 Commercial

The FCC has imposed requirements in the U.S. for many years on radiated characteristics from equipment antennas. The FCC first introduced requirements on more general types of electronics in 1979 for "computing devices" in the CFR 47, Docket 20780. The requirements used today are essentially the same and are limited to conducted emissions on power interfaces and radiated emissions. The FCC does not yet mandate immunity requirements for general electronics. Significant changes are occurring in the commercial world because of the EMC Directive 89/336/EEC, which was issued by the European Union (EU) and became effective as of January 1, 1996. This directive requires equipment sold in Europe to meet both emission and immunity requirements. U.S. manufacturers who wish to sell their products in Europe must meet these requirements. This situation has prompted greater interest in the U.S. in establishing voluntary immunity requirements on equipment.

D.3.3 Summary of Relevant EMC/EMI Standards

Significant differences exist between the military and the various commercial standards, not only in the ways that requirements are specified, but also in the test methodologies that are implemented. These differences present major challenges in making comparisons and are treated in detail in the EPS. A summary of the major aspects of various standards is presented below.

D.3.3.1 Military

MIL-STD-461E specifies requirements and limits based on platform types (that is, surface ships, aircraft, and so forth), location of equipment in the platform (for example internal or external to the structure), and unique platform features, such as anti-submarine warfare capability. Although tailoring of the requirements is encouraged for individual procurements, MIL-STD-461E is structured to provide a reasonable set of default requirements if tailoring is not specified. It also provides a standardized test methodology, which is consistent among the various requirements. There are setup conditions that are common to all the tests, such as ground plane usage, electrical cable construction and routing, and power line treatment.

D.3.3.2 Commercial

A variety of commercial standards are discussed in the EPS report. The most predominant are those established by the European Community. Other standards are FCC regulations, RTCA DO-160D, and those issued by ANSI.

D.3.3.2.1 International Standards

IEC, CISPR, and the International Organization for Standardization (ISO) have published the most significant standards. CISPR standards primarily limit emissions, both conducted and radiated that are capable of causing interference to radio, television, and other radio services. The devices creating the emissions are categorized in various ways. The IEC Technical Committee (TC) 77 is concerned with emissions below 9 kHz and has established basic immunity measurement techniques over the entire frequency range. In addition, various IEC technical committees concerned with specific products prepare EMC standards for these products. Similarly, ISO technical committees prepare EMC standards. Examples are TC 20 for aircraft and TC 22 for motor vehicles.

a. European Union (EU). The EU EMC efforts are extensive and complicated. The EU EMC Directive specifies general requirements that equipment be designed and built to achieve the following:

- The electromagnetic disturbance that the equipment generates should not prevent radio and telecommunications equipment and other apparatus from operating as intended.

- The equipment has an adequate level of intrinsic immunity from electromagnetic disturbances to enable it to operate as intended.

The European Committee for Electrotechnical Standardization (CENELEC) is largely responsible for approving detailed standards that are acceptable for demonstrating compliance with the EMC Directive. Most, but not all, CENELEC standards are identical to, or contain only minor deviations from, those developed by the IEC and CISPR. All of the European documents discussed in the EPS report are either IEC or CISPR standards. All are not yet adopted by CENELEC. Immunity test procedures covered in the basic IEC standards tend to be written so that there is flexibility in applying them, depending on the particular application. Also, a range of suggested limits is generally given. The manufacturer or some other authority must specify a particular level for certification. Another characteristic of these documents is that each tends to stand alone regarding test methodology. They do not have the same consistency among test setups as those specified in the MIL-STD-461E.

b. CE Mark. Products sold in Europe must comply with a number of EU directives and contain the “CE” mark as an indication of compliance. For electronic products, this mark indicates compliance with both Low Voltage Directives, 73/23/EEC and 93/68/EEC, which address electrical safety, and the EMC Directive. The following discussion concentrates on aspects of the EMC Directive. Several paths can be followed for compliance. One approach is a self-declaration where the manufacturer issues a "Declaration of Conformity" that the product complies without third party participation. This declaration should be available upon request and must list the specifications used to demonstrate compliance. When complications exist, a technical construction file is produced containing the details of the methods for complying with the EMC Directive. It is submitted it to a "Competent Body" for approval. The self-declaration is apparently the most common path for items that clearly fall under a particular generic or product standard (see below). The self-declaration is more risky for the manufacturer in the event that compliance is challenged. The CE mark indicates that a decision has been made by someone that the equipment meets the broad intent of the wording in the EMC Directive. It does not necessarily indicate what specific tests have been performed or what specific limits have been met.

c. Generic Standards. The IEC has issued a number of generic standards, IEC 61000-6-1, 2, 3, and 4, which specify emission and immunity requirements for two classes of equipment: "residential," which includes commercial and light industrial, and "industrial." The generic standards may be used when a "product" standard that addresses the particular item does not exist. The generic standards list the individual test standards, generally IEC and CISPR documents that are applicable, and the limits that apply.

d. Product Standards. These standards are prepared by product committees who determine what requirements must be applied for a particular product or product family to meet the intent of the EMC Directive. To determine the appropriate requirements, these committees review the application of the product and its intended electromagnetic environments. The selected requirements generally will be derived from the IEC and CISPR standards.

D.3.3.2.2 United States National Standards

In the U.S., the FCC controls non-Government use of the frequency spectrum. Emissions below 9 kHz and immunity of equipment are controlled by a variety of commercial "voluntary" standards.

a. FCC. For certain types of non-transmitting electronics, most notably computers, the FCC has issued requirements presently contained in CFR 47, Part 15, which are similar to CISPR 22. The requirements are limited to conducted emissions on commercial AC power lines and radiated emissions. There are two sets of limits, one for residential areas and a second for industrial areas. Separate FCC requirements in CFR 47, Part 18 are applicable to industrial, scientific, and medical equipment that intentionally uses RF energy in its basic operation. These are similar to CISPR 11. Requirements for Part 18 are limited to radiated emission controls that are dependent on the characteristics of the RF source.

b. ANSI. Test methodology for certifying equipment as meeting requirements in CFR 47, Part 15, is provided in ANSI/IEEE C63.4, prepared by the American National Standards Committee C63. In addition, ANSI/ IEEE C63.12 contains guidance in selecting immunity for three classes of equipment: residential, industrial, and those in severe environments. Other C63 standards cover instrumentation, site and antenna calibration, and other related topics.

c. RTCA DO-160D. DO-160D is used by the commercial airline industry to qualify equipment as part of FAA certification of aircraft. Among commercial standards, DO-160D is the commercial standard most similar to MIL-STD-461E. The test methodology addresses many issues that are also important in MIL-STD-461E, including ground planes, electrical cabling, and consistency among setups. DO-160D provides a number of different categories that equipment can be certified to, depending on the type of equipment, its installation location, and the desires of the equipment and aircraft manufacturers.

d. Other Commercial Standards. Many standards covering specialized topics are produced under the auspices of various professional and trade organizations. Because of their specialized nature, they are not specifically compared in the EPS report with MIL-STD-461E. The EPS report, in some cases, provides a broad evaluation of the standards. As an example, the EPS report notes that fourteen SAE J1113 series standards covering motor vehicles were screened for homogeneity to requirements and test methods specified in MIL-STD-461E. The result was that none of these standards could be accepted as replacements for MIL-STD-461E requirements without modification of some performance parameter, but the test methodology for each of the fourteen is identical to the corresponding MIL-STD-461E test method.

D.3.3.3 Differences Between Commercial and Military Standards

Major reasons for the most significant differences between commercial and military EMC standards are as follows:

- Requirements for submarines are unique because of critical dependence on the reception of lower frequencies of electromagnetic signals.

- There is a large concentration of electronic equipment, including high-power emitters and very sensitive receivers, aboard ships and other military platforms. For this reason, military radiated emission limits are more severe than corresponding civilian limits. The military also places high immunity requirements on devices exposed to nearby intentional emitters.

- Military platforms have the general availability of grounded conducting surfaces such as ground planes for mounting equipment, whereas most civilian equipment is mounted on an ungrounded tabletop. However, this difference is not pervasive, for example, floor-mounted civilian equipment is frequently bonded to a ground plane.

- Some frequency ranges are more extensive in military requirements than they are in commercial requirements, hence, if equipment is tested to meet civilian requirements, additional testing may be needed for military use.

These significant differences make it impossible to find commercial qualified equipment that is completely equivalent to equipment meeting military requirements. This means that a detailed analysis is required to determine the adequacy of equipment tested to civilian requirements versus the requirements of a particular military environment.

D.3.4 Selection of Commercial Items for Military Use

In selecting CI for military purposes, the Program Office must relate the characteristics of the anticipated EME to the characteristics of the equipment under consideration. In order to determine if a CI is adequate for a particular military application, it is necessary to accomplish the following:

- Determine which commercial standards are applicable to the equipment,

- Evaluate whether the commercial standards are adequate for the intended use, and

- Determine, if necessary, which additional requirements should be imposed.

D.3.4.1 Decision Process

Ideally, the overall decision process that should be used to evaluate the adequacy of any item for an intended military application is illustrated in Figure D-1. The process is similar for both military and commercial equipment. The performance requirements should take into account whether the performance of the equipment is safety or mission critical. The process must consider both the potential impact of externally imposed EMI on equipment and the impact of emissions from the equipment to other equipment.

D.3.4.2 Anticipation of the Environment

In order to evaluate the applicability of commercial standards for military purposes, it is necessary to define, as indicated in Figure D-1, the EME in which the equipment will operate. Examples of areas that may be considered to have particular environmental characteristics include ship topside, ship below deck, submarines, aircraft carriers, aircraft external, aircraft internal, ground combat, and so forth. In a traditional military procurement, the acquisition personnel would assess the anticipated use of the equipment and levy appropriate requirements from MIL-STD-461, tailored as necessary to match the anticipated EME. The equipment would then be designed to meet these requirements and would be tested accordingly. However, if existing CI is to be utilized, the availability of test data must be determined, whether the data describes the electromagnetic characteristics of that equipment, and how well those characteristics meet anticipated needs. Thus, it is most expedient to use MIL-STD-461 as the basic reference for establishing EMI requirements as shown in Figure D-1. The procedure then deviates, depending on whether the equipment is a military type or CI. If the latter, a complex evaluation process should be initiated. Guidance for such an evaluation is the subject of the EPS report.

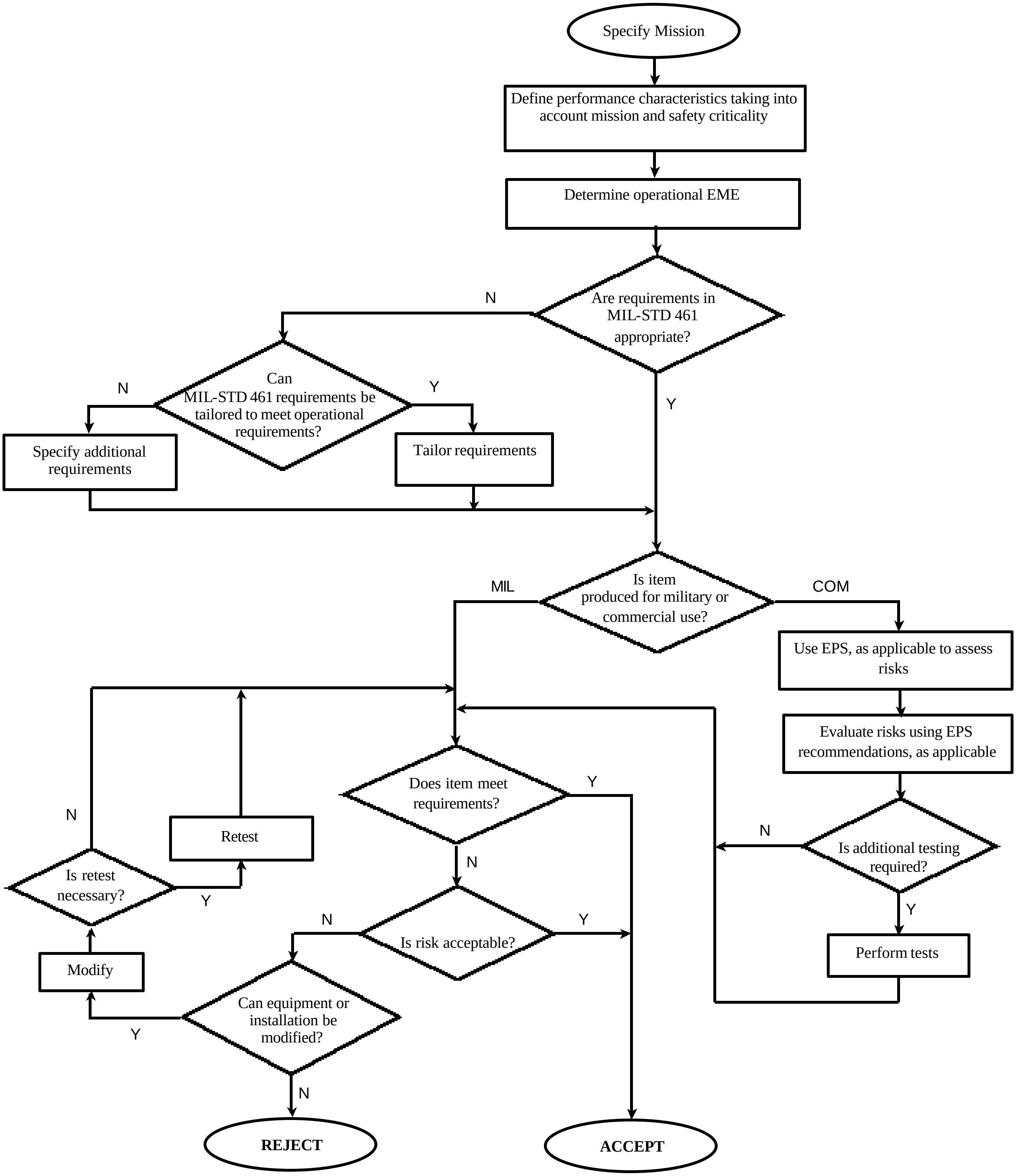

FIGURE D-1. Defining Applicable EMI Requirements.

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CONCLUDING MATERIAL

Custodians:

Army - CR
Navy - EC
Air Force - 11

Preparing Activity:

DISA (DC5)
(Project EMCS - 0176)

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STANDARDIZATION DOCUMENT IMPROVEMENT PROGRAM

INSTRUCTIONS

1. The Preparing Activity *must* complete blocks 1,2,3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4,5,6, and 7.
3. The Preparing Activity must provide a reply within 45 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, waivers, or clarification of requirements on current contracts. Comments submitted on this request form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

1. RECOMMENDED CHANGE	1. DOCUMENT NUMBER MIL-HDBK-237C	2. DOCUMENT DATE (YYMMDD)

3. DOCUMENT TITLE

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS AND SPECTRUM CERTIFICATION GUIDANCE FOR THE ACQUISITION PROCESS

.4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION:

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME	b. TELEPHONE (Include Area Code
DISA/JSC J5	1) Commercial (410) 293-4958 (2) AUTOVON (if applicable)
c. ADDRESS (Include Zip Code) DISA/Joint Spectrum Center 2004 Turbot Landing Annapolis, MD 21402-5064	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church VA 22041-3466 Telephone: (703) 756-2340 AUTOVON 289-2340

DD FORM 1426